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"RECOMMENDATIONS GUIDELINES, AND REQUIREMENTS TO DESIGN SHEET PILES WALLS MADE OF STEEL PIPE PILES, H-BEAM SHEET PILES AND SHEET PILES COMBINATION WALLS WITH STEELWALL ISH GMBH INTERLOCKING SYSTEM CLUTCH BARS AND RECOMMENDATIONS FOR APPLICATION THESE SYSTEMS FOR DIFFERENT KIND OF STRUCTURES WHERE EXTREMELY STABLE STEEL SUPPORT AND STEEL-RETENTION WALLS REQUIRED IN UKRAINE"

Contract No.01/ukr/1023

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2024

1 GENERAL PROVISIONS

1.1 “Recommendations Guidelines, and Requirements to design sheet piles walls made of steel pipe piles (hereinafter referred to as ШТЗ), H-beam sheet piles (hereinafter referred to as ШБЗ) and sheet piles combination walls with STEELWALL ISH GMBH interlocking system clutch bars and Recommendations for Application of these systems" (hereinafter referred to as the “Recommendations Guidelines…” are developed by “CHORNOMORNDIPROEKT” Branch of State Enterprise “Ukrainian Sea Ports Authority in accordance with the Program of Execution attached to an archival copy.

1.2 The “Recommendations Guidelines…” are developed in compliance with the rules established in the national standardization system of Ukraine.

1.3 The “Recommendations Guidelines…” are first developed and do not require cancellation or amendment to any existing regulatory act of Ukraine.

1.4 The “Recommendations Guidelines…” cover the design of steelwork for buildings and structures (hereinafter referred to as the structures) of various purposes, which operate at environment temperature not exceeding 100°C.

1.5 When designing the steelwork that are in specific operational conditions, it is vital to comply with additional requirements, which reflect specific features of these structures operation and provided by corresponding Building Codes and regulations.

1.6 The “Recommendations Guidelines…” do not cover search of technical solutions and activities of steelwork special protection (fire protection, secondary corrosion protection, explosion protection, etc.).

2 REFERENCES TO STANDARD DOCUMENTS

The following Ukrainian standards and European regulations valid in Ukraine should be used when performing the work.

1) ДБН В.2.4-3-2010. Гідротехнічні споруди. Основні положення. (Hydraulic Structures. General Provisions).

2) ДБН В.1.2 2006. Навантаження і впливи. (Loads and Impacts).

3) ДБН В.2.6-198_2014 Сталеві конструкції. Норми проектування. (Steel Structures. Design Standards).

4) ДБН-В.1.2-6-2021. Механічний опір та стійкість. (Mechanical Resistance and Stability).

5) ДБН В.1.2-14-2018. Загальні принципи забезпечення надійності та конструктивної безпеки будівель і споруд. (General Principles of Ensuring the Reliability and Structural Safety of Buildings and Structures).

6) ДСТУ-Н Б В.1.2-13:2008.(EN 1990:2002, IDN). Настанова. Основи проектування конструкцій. (Guidelines. Fundamentals of Structural Design).

7) ДСТУ-Н Б EN 1991-1-2:2010.Єврокод 1: Дії на конструкції (Eurocode 1: Actions on Structures).

8) ДСТУ-Н Б EN 1993-1-3:2012. Єврокод 3: Проектування сталевих конструкцій (Eurocode 3: Design of Steel Structures).

9) ДСТУ-Н Б EN 1997-1:2010.Єврокод 7: Геотехнічне проектування/ (Eurocode 7: Geotechnical Design).

10) ДСТУ-Н Б EN 1998-1:2010.Єврокод 8: Проектування конструкцій при сейсмічному навантаженні. (Eurocode 8: Design of Structures for Earthquake Resistance).

11) ДСТУ-Н Б EN 1993-1-6:2011. Єврокод 3. Проектування сталевих конструкцій. Міцність та стійкість оболонок. (Eurocode 3: Design of Steel Structures. Strength and Stability of Shell Sructures).

12) ДСТУ-Н Б EN 1993-1-7:2012. Єврокод 3. Проектування сталевих конструкцій. Частина 1-7. Пластинчасті конструкції при навантаженні поза межами площини (EN 1993-1-7:2007, IDT)/ (Eurocode 3. Design of Steel Structures. Part 1-7. Plated Structures subject to Out of plane Loading).

13) ДСТУ-НБ EN 1993-1-8:2011.Єврокод 3:Проектування сталевих конструкцій. Проектування з'єднань. (Eurocode 3: Design of Steel Structures. Calculation of Joints.)

14) ДСТУ-НБ EN 1993-1-9:2012. Єврокод 3:Проектування сталевих конструкцій. Втомна міцність сталевих конструкцій. (Eurocode 3: Design of Steel Structures. Fatigue Strength of Steel Structures).

15) ДСТУ-НБ EN 1993-1-10:2012. Єврокод 3:Проектування сталевих конструкцій. Частина 1-10. Властивості тріщиностійкості і міцності матеріалу у напрямі товщини

прокату. (Eurocode 3: Design of Steel Structures. Part 1-10. Material toughness and Through-thickness Properties).

16) ДСТУ ISO 18275:2008.Покриті електроди для ручного дугового зварювання високоміцних сталей. (Coated Electrodes for Manual Arc Welding of High-strength Steels).

17) ДСТУ EN ISO 9692-1 (ГОСТISO 9 6 9 2-1-2016). Зварювання та споріднені процеси. Частина1.Типи підготовки з'єднань. (Welding and Related Processes. Part 1: Types of Joint Preparation).

18) ДСТУ EN ISO 9692-2 (ГОСТ ISO 9 6 9 2-2-2020). Зварювання та споріднені процеси. Типи підготовки з'єднань. Частина 2. Зварювання дугове сталей під флюсом. (Welding and Related Processes. Types of Joint Preparation. Part 2. Submerged Arc Welding of Steels)

19) ДСТУ EN 10210-1:2009. Профілі порожнисті гарячого оброблення з нелегованих і дрібнозернистих сталей для конструкцій. Частина 1. Технічні умови постачання (EN 10210-1:2006, IDT) (Hot Finished Structural Hollow Sections of Non-Alloy and Fine Grain Steels. Part 1: Technical delivery conditions).

20) ДСТУ EN 10219-1:2009 Профілі порожнисті зварні холодного формування з нелегованих і дрібнозернистих сталей для конструкцій. Частина 1. Технічні умови постачання (EN 10219-1:2006, IDT). (Cold Formed Welded Structural Hollow Sections of Non-alloy and Fine Grain Steels. Part 1: Technical delivery conditions).

21) ДСТУ 8943:2019 Труби сталеві електрозварні. Технічні умови. (Electric-Welded Steel Pipes. Technical Specifications).

22) ДСТУ 7809:2015 (ГОСТ 1050-88). Прокат сортовий, калібрований зі спеціальним обробленням поверхні з вуглецевої якісної конструкційної сталі. Загальні технічні умови. (Rolled sections, Calibrated with Special Surface Treatment, Made of High-quality Carbon Structural Steel. General C).

23) ДСТУ Н Б В.1.1-27:2010 Захист від небезпечних геологічних процесів, шкідливих експлуатаційних впливів, від пожежі. Будівельна кліматологія. (Protection against Hazardous Geological Processes, Harmful Operational Impacts, and Fire. Building Climatology).

24) ДСТУ 4484:2005/ГОСТ 535-2005 Прокат сортовий і фасонний зі сталі вуглецевої звичайної якості. Загальні технічні умови. (Long products and profile of carbon steel of ordinary quality. General Specifications).

25) ГОСТ 28870-90. Сталь. Методи випробування на розтягування товстолистового прокату в напрямку товщини. (Steel. Tensile Testing Through-thickness Methods for Rolled Plates).

26) ДСТУ ISO 12944-4:2015 Фарби та лаки. Захист від корозії сталевих конструкцій захисними лакофарбовими системами. Частина 4. Типи поверхні та підготовка поверхні

(ISO 12944-4:1998, IDT). (Paints and Varnishes. Corrosion Protection of Steel Structures with Protective Paint and Varnish Systems. Part 4. Surface Types and Surface Preparation).

27) ДСТУ 8540:2015 Прокат листовий гарячекатаний. Сортамент. (Hot-rolled Steel Sheets. Steel Grades).

28) ДСТУ 8803:2018 Прокат товстолистовий із вуглецевої сталі звичайної якості. Технічні умови. (Heavy Plates Made of Carbon Steel of Ordinary Quality. Technical Specifications).

29) ДСТУ 8541:2015 Прокат сталевий підвищеної міцності. Технічні умови. (High-strength Rolled Steel. Technical Specifications).

30) ДСТУ 8539:2015 Прокат для будівельних сталевих конструкцій. Загальні технічні умови. (Rolled Steel for Steel Structures Purposed for Construction. General Technical Specifications).

31) ДСТУ 9129:2021 Металопродукція. Правила приймання, маркування, пакування, транспортування та зберігання. (Metal Products. Rules for Acceptance, Labeling, Packaging, Transportation and Storage).

32) EN 12063:1999 – Execution of Special Geotechnical Work.

33) ДСТУ Б EN 1090-1:2014 Вимоги до оцінки відповідності компонентів конструкцій (Requirements for Conformity Assessment of Structural Components) (EN 1090-Виконання сталевих і алюмінієвих конструкцій. Частина 1.1:2009+A1:2011, IDT). (Execution of Steel and Aluminum Structures. Part 1.1:2009+A1:2011, IDT).

34) ДСТУ EN 1090-2:2019 Виконання сталевих та алюмінієвих конструкцій. Частина 2. Технічні вимоги до сталевих конструкцій (EN 1090-2:2018, IDT). (Execution of Steel and Aluminum Structures. Part 2. Technical Requirements to Steel Structures).

35) ДСТУ EN 1090-4:2019 Виконання сталевих та алюмінієвих конструкцій. Частина 4. Технічні вимоги до холодноформованих сталевих будівельних елементів та конструкцій для покрівель, стель, підлог і стін (EN 1090-4:2018, IDT). (Execution of Steel and Aluminum Structures. Part 4. Technical Requirements to Cold-formed Steel Elements and Structures for Roof, Ceiling, Floor and Wall Applications).

36) ДСТУ 2651:2005 Сталь вуглецева звичайної якості. Марки (ГОСТ 380-2005). (Carbon Steel of Ordinary Quality. Grades).

37) ДСТУ 9219:2023 Труби сталеві зварні для магістральних газонафтопроводів. Технічні умови. (Welded Steel Pipes for Main Gas and Oil Pipelines. Technical Specifications).

38) ДСТУ 8818:2018. Прокат листовий. Методи ультразвукового контролю. (Rolled Sheet Steel. Methods of Ultrasonic Control).

39) ДСТУ 8938:2019. Труби сталеві безшовні гарячедеформовані. Технічні умови. (Hot-formed Seamless Steel Pipes. Technical Specifications).

3 THE MAIN TYPES OF STRUCTURAL ELEMENTS USED

3.1 Steel pipe piles walls (ШТЗ).

3.2 H-beam sheet piles (ШБЗ).

3.3 Sheet piles combination walls with STEELWALL ISH GMBH interlocking system clutch bars

4 SPHERE OF APPLICATION

4.1 Application of sheet piles mentioned in Article 3 is considered in the following areas: by service life; by purpose; by field of application, and by method of driving.

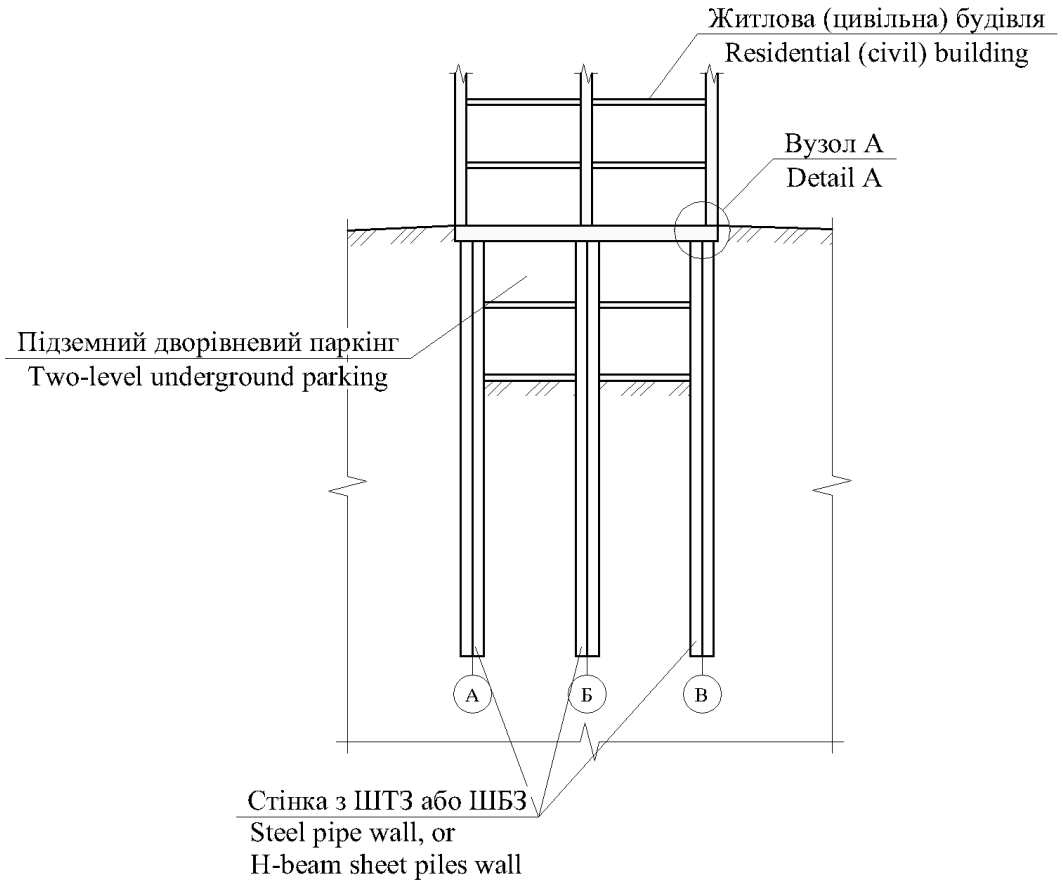
4.2 Structures are divided into permanent and temporary according to their service life. Structural elements of permanent structures should provide adequate strength and stability for the entire service life. Design of structures with a service life of 100 years or more shall specify additional requirements to ensure the standard service life. When included to design of temporary structures, the requirements for anti-corrosion coating and other requirements affecting the structure life may be reduced or eliminated. Design of temporary structures shall specify the turnover of specific structures.

4.3 Structures are divided into basic and supporting structures according to their purpose. This division affects the application of additional coefficients in the calculation of structures.

4.4 The structures can be used in all areas of construction, including residential construction, for example, in construction of underground parking lots (Fig. 4.1); in civil construction (Fig. 4.2); in industrial construction (Fig. 4.3); in hydroengineering, for example, in construction of berthing structures (Pics. 4.4 and 4.5), breakwaters within harbours (Pics. 4.6 and 4.7), or coast protecting structures along rivers and canals (Fig. 4.8); in flood protection; in bridge construction (Fig. 4.9) and roads construction (Fig. 4.10); in construction of retaining walls (Fig. 4.11), subways (Fig. 4.12); in onshore and offshore construction of cofferdams; as well as in other types of structures, including underground structures, where the feasibility of these structures application will be calculated by the design.

4.5 When choosing a constructive scheme for a structure, the metod of driving: hammering, vibration, or DTH method, should be taken into account. That allows for vertical or horizontal work performance. In addition to economic factors, the choice of driving method depends on soil conditions, equipment of the contractor, mastery of construction technology and other factors that could influence the choice of driving method.

4.6 Recycled materials are allowed to be used for manufacture of steel pipe piles (ШТЗ), and H-beam sheet piles (ШБЗ). For this purpose, the relevant articles define the conditions and provide restrictions on their use.



Detail A

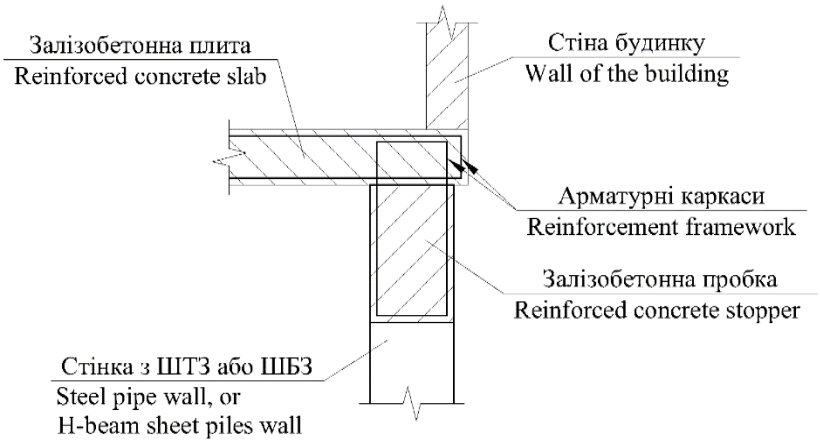


Fig. 4.1 Example of steel pipe piles and H-beam sheet piles application in in residential and civil construction. Underground parking.

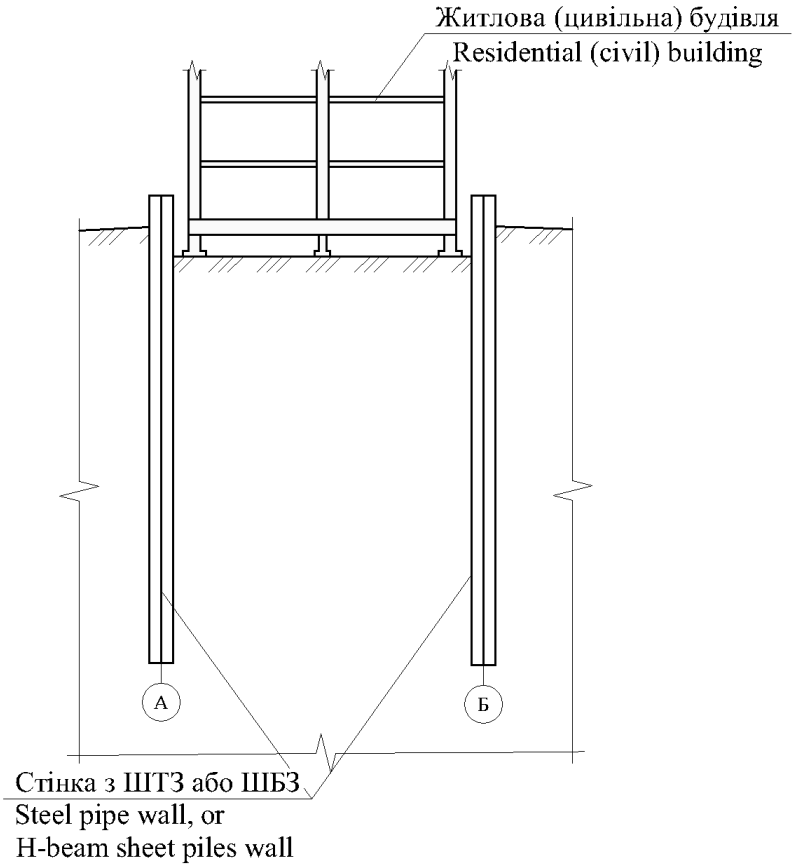
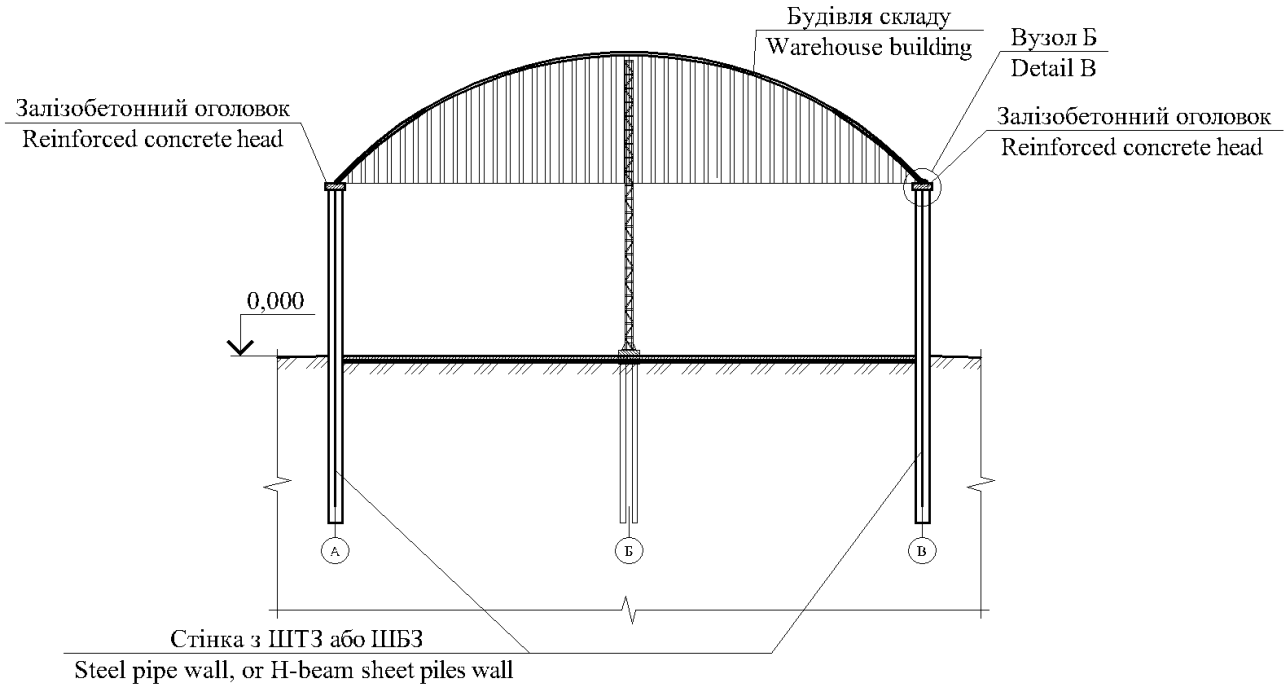


Fig.4.2 Example of of steel pipe piles and H-beam sheet piles application in in residential and civil construction. Temporary fencing of the pit.



Detail B

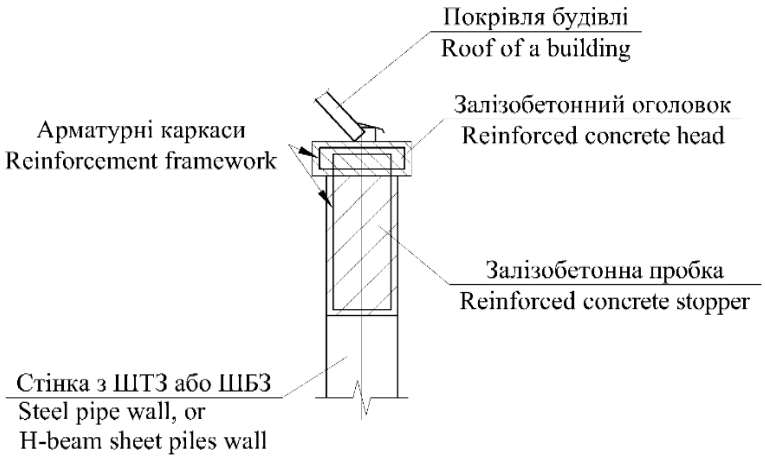
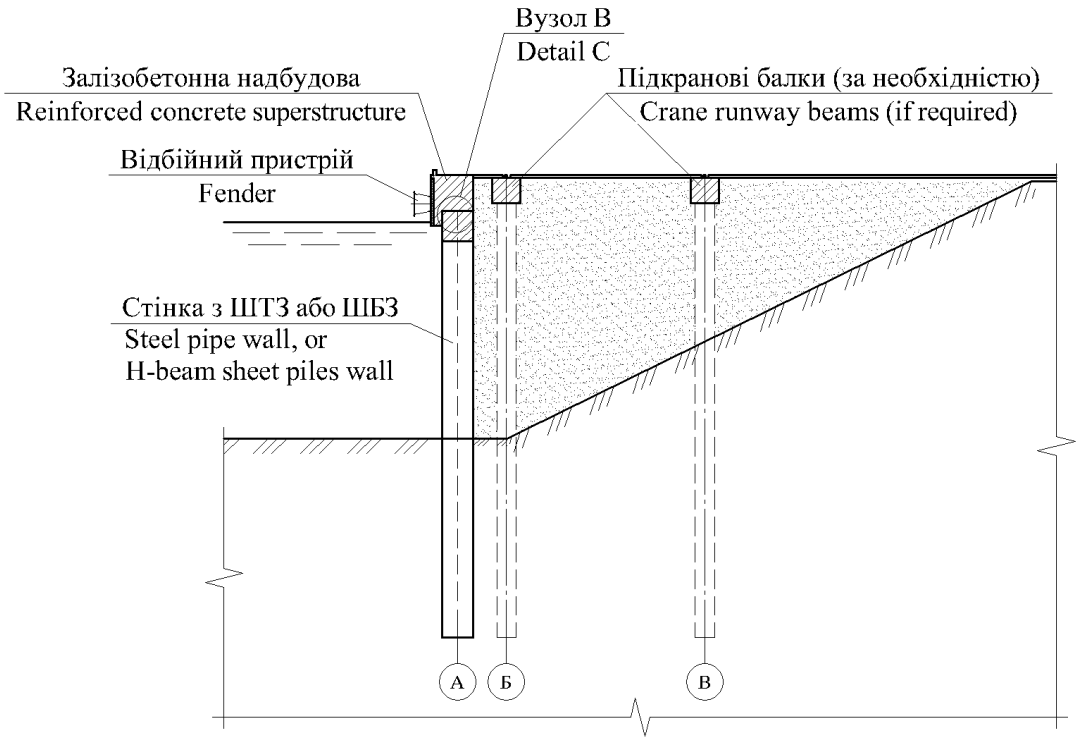


Fig.4.3 Example of steel pipe piles and H-beam sheet piles application in industrial construction. Storehouse.



Detail C

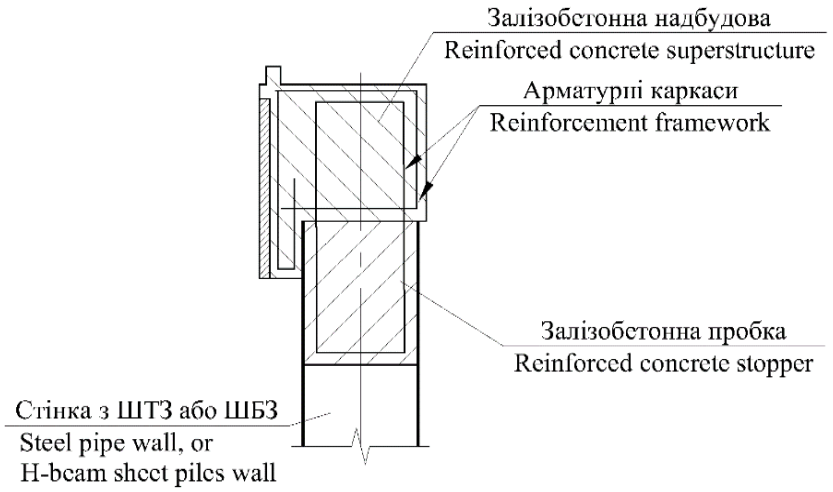
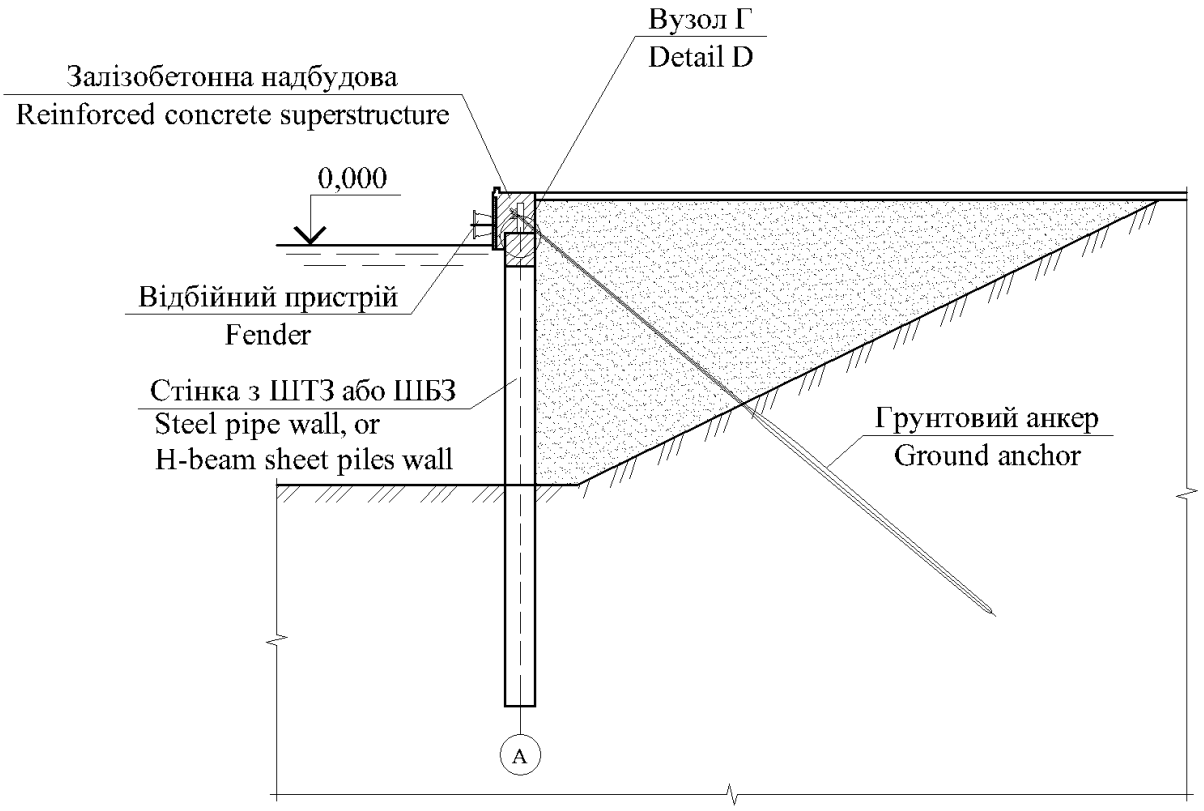
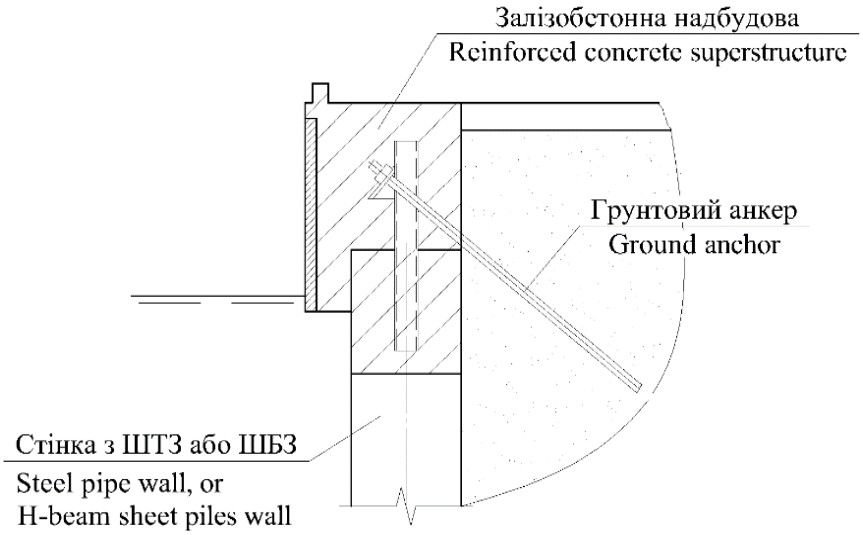


Fig.4.4 Example of steel pipe piles and H-beam sheet piles application in hydroengineering. Berthing structure – unanchored piled quay wall.

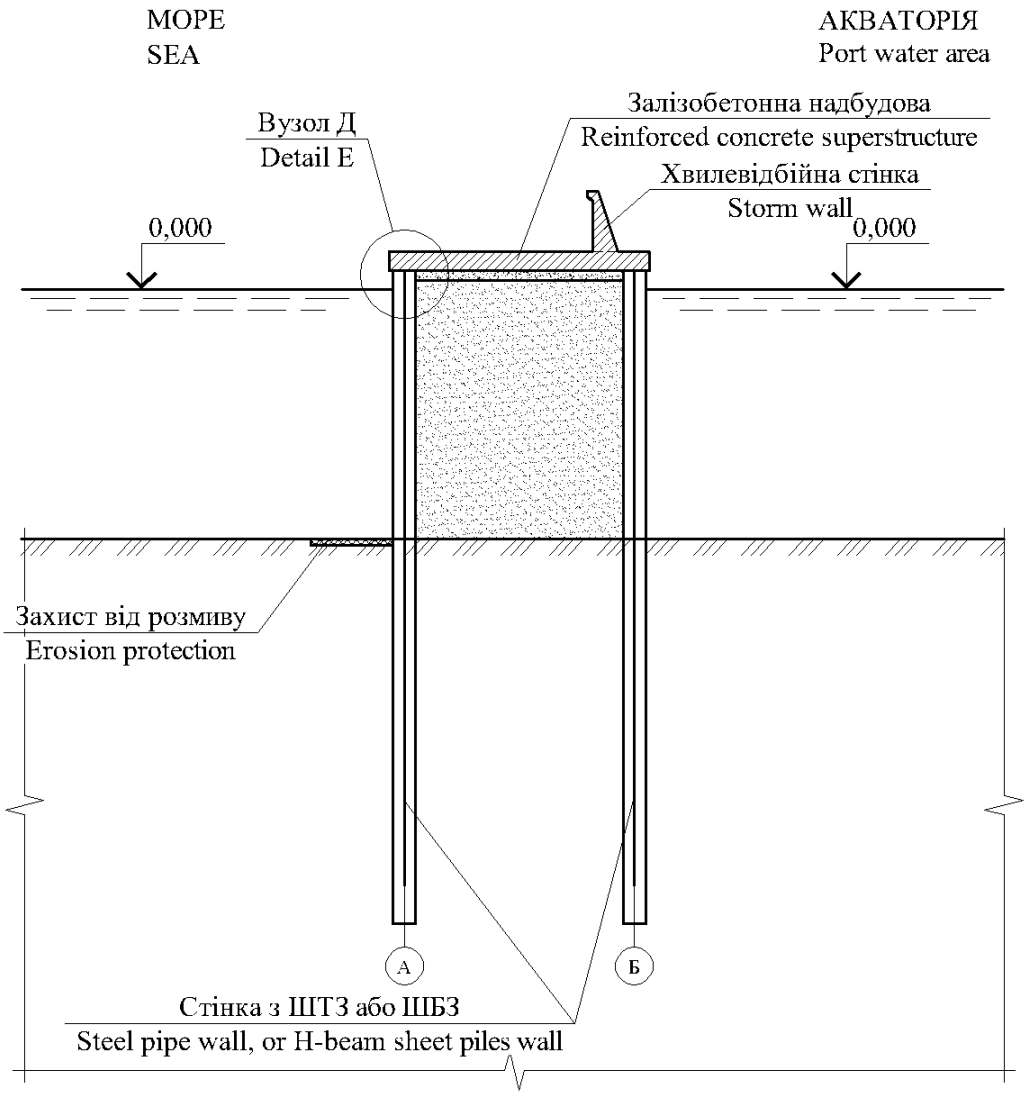


Detail D

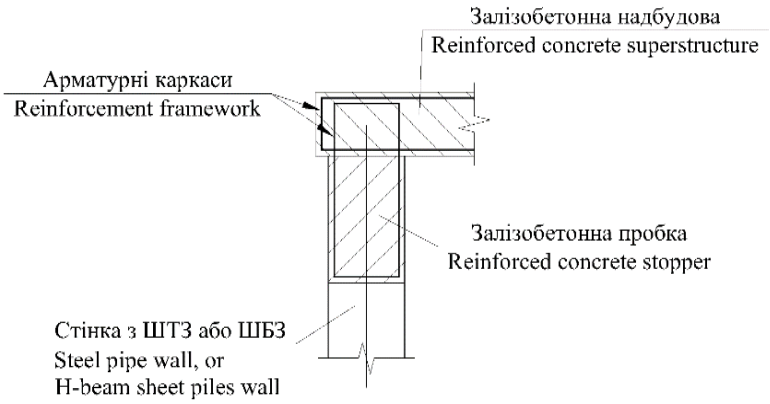


Note: Anchorage type to be defined while designing.

Fig.4.5 Example of steel pipe piles and H-beam sheet piles application in hydroengineering. Berthing structure – anchored piled quay wall.

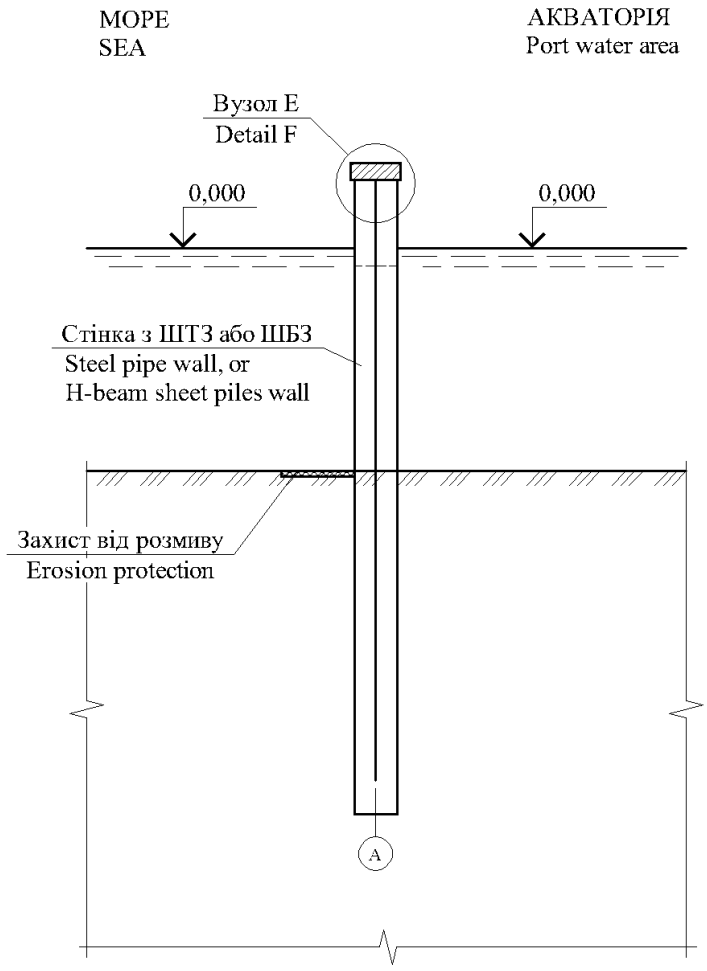


Detail E



Note: The location of a storm wall to be specified depending upon functional purposes of a facility

Fig. 4.6 5 Example of steel pipe piles and H-beam sheet piles application in hydroengineering. Breakwater.



Detail F

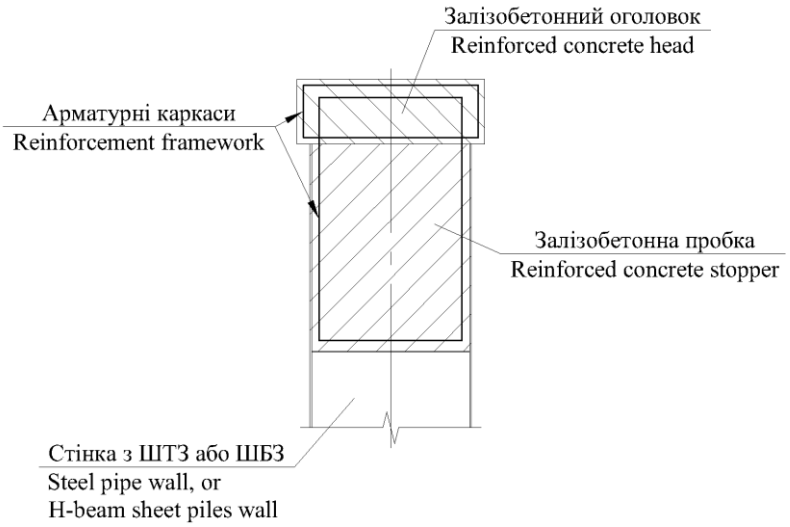
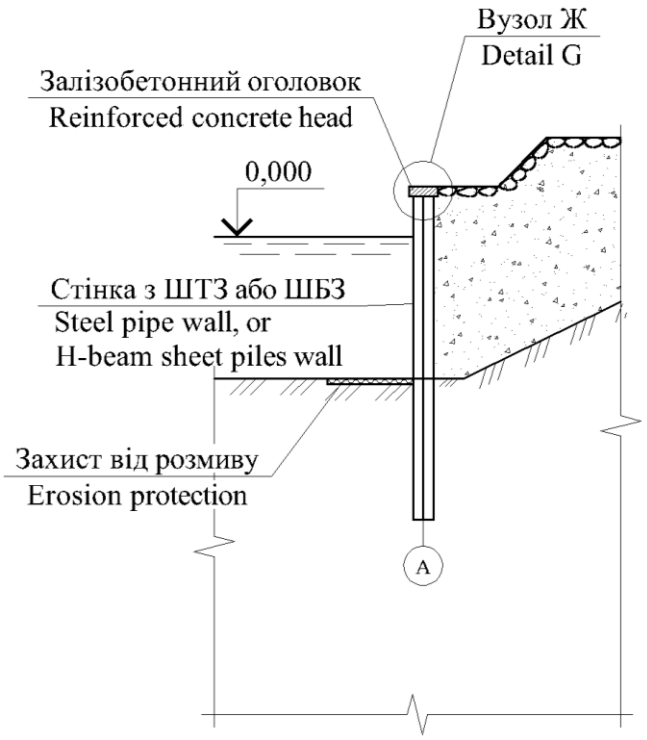


Fig.4.7 Example of steel pipe piles and H-beam sheet piles application in hydroengineering. Breakwater



Detail G

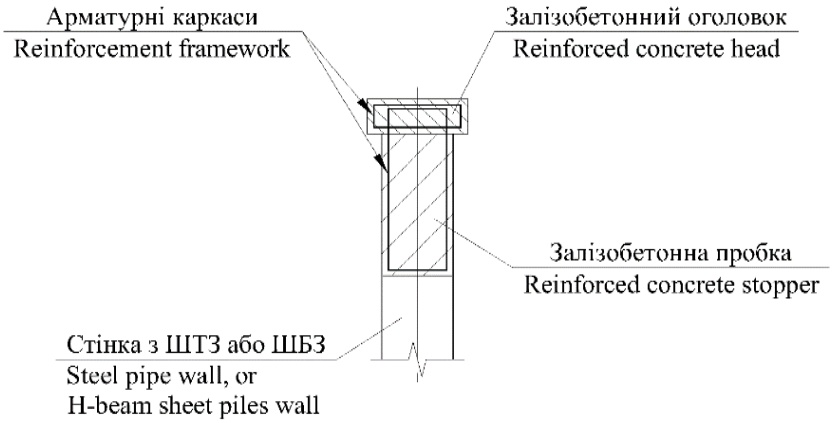


Fig. 4.8 Example of steel pipe piles and H-beam sheet piles application in hydroengineering. Coast protection along rivers and canals

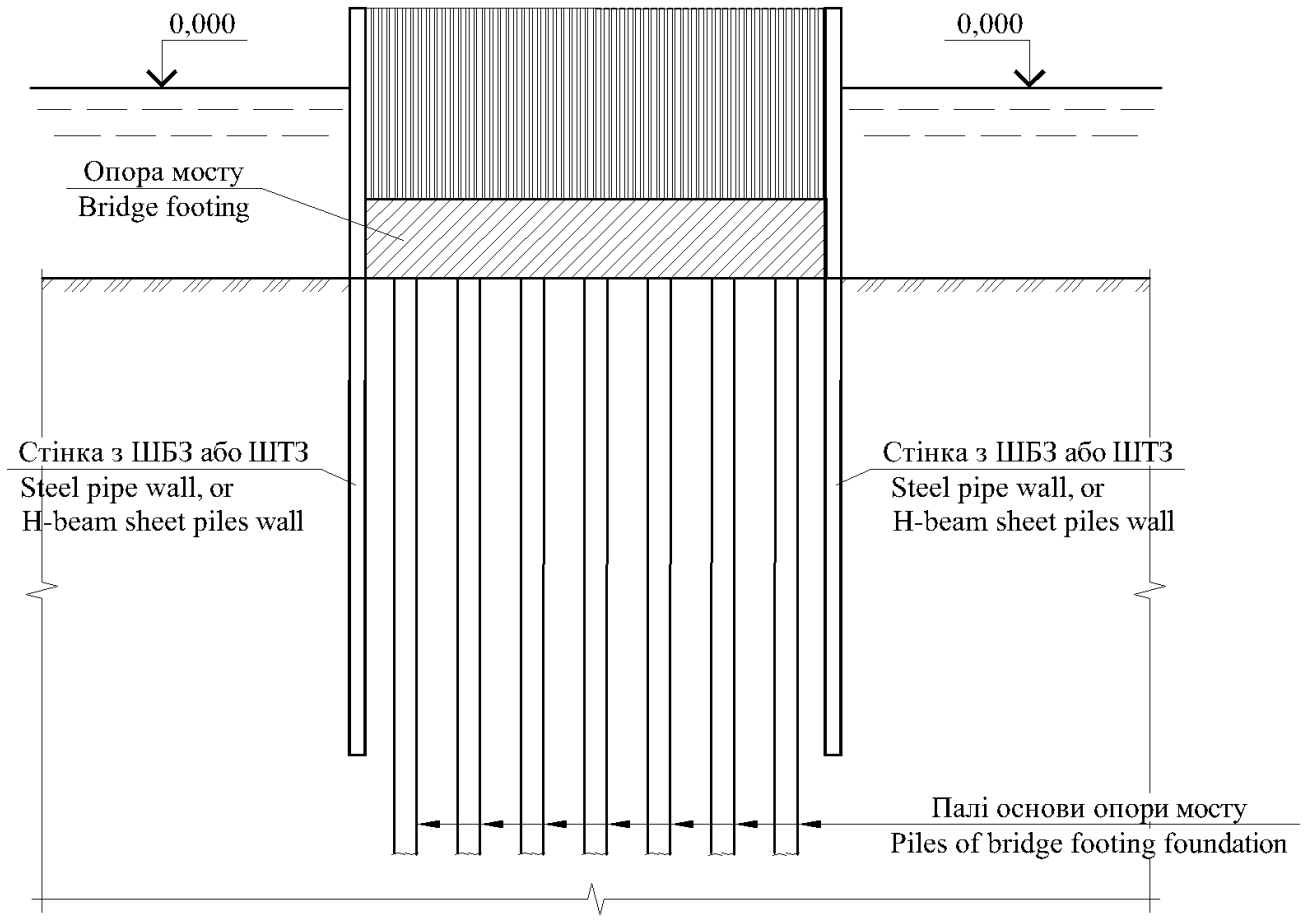
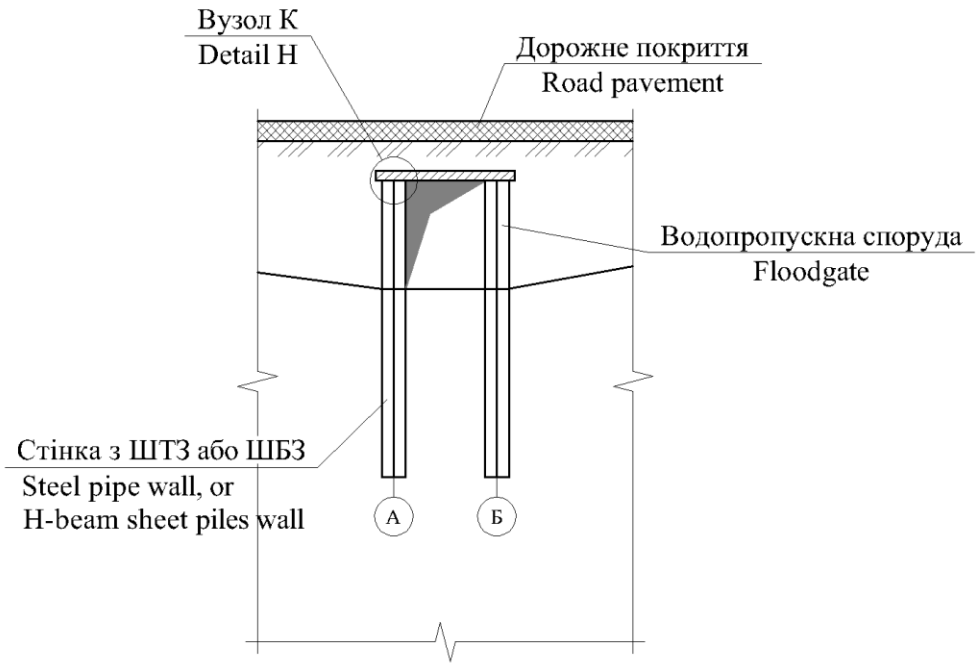


Fig. 4.9 Example of steel pipe piles and H-beam sheet piles application in bridge construction. Arrangement of bridge footing.



Detail H

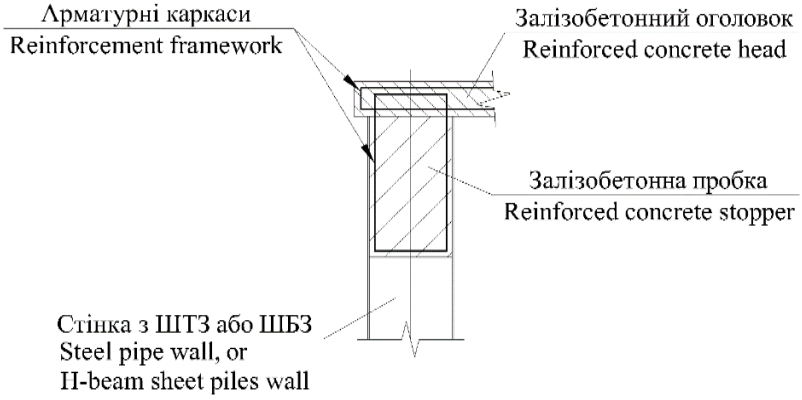
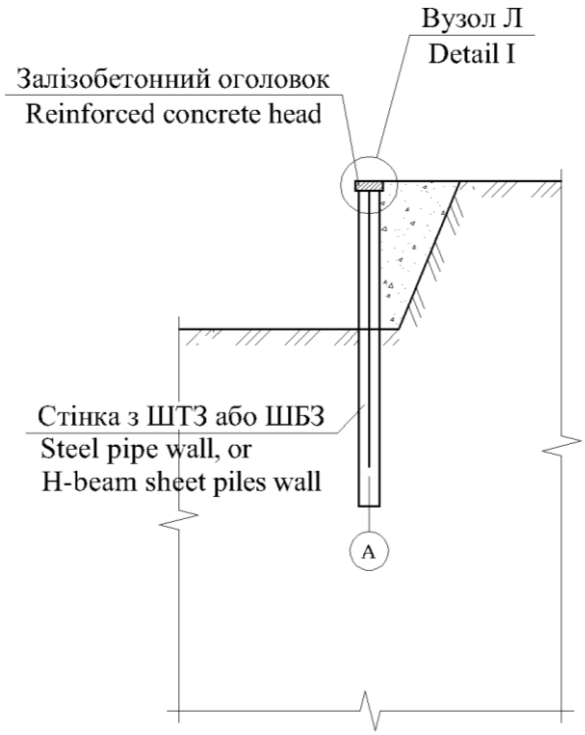


Fig. 4.10 Example of steel pipe piles and H-beam sheet piles application in roads arrangement. Floodgate.



Detail I

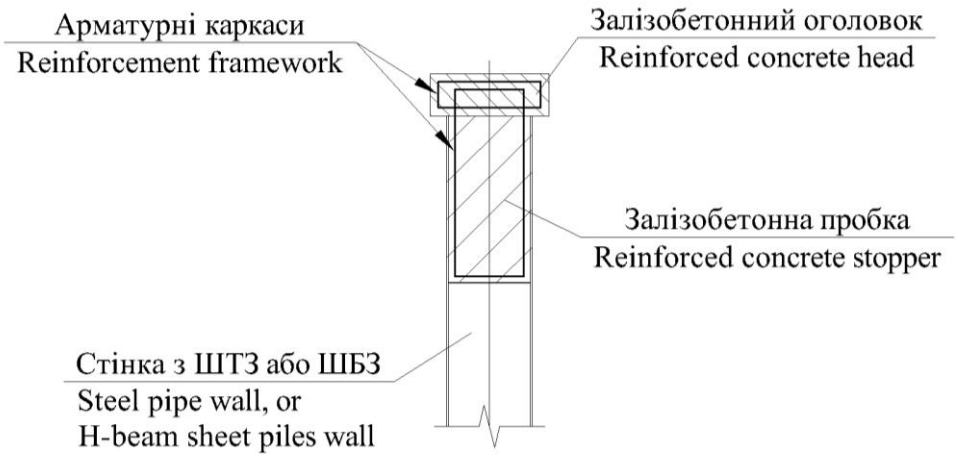
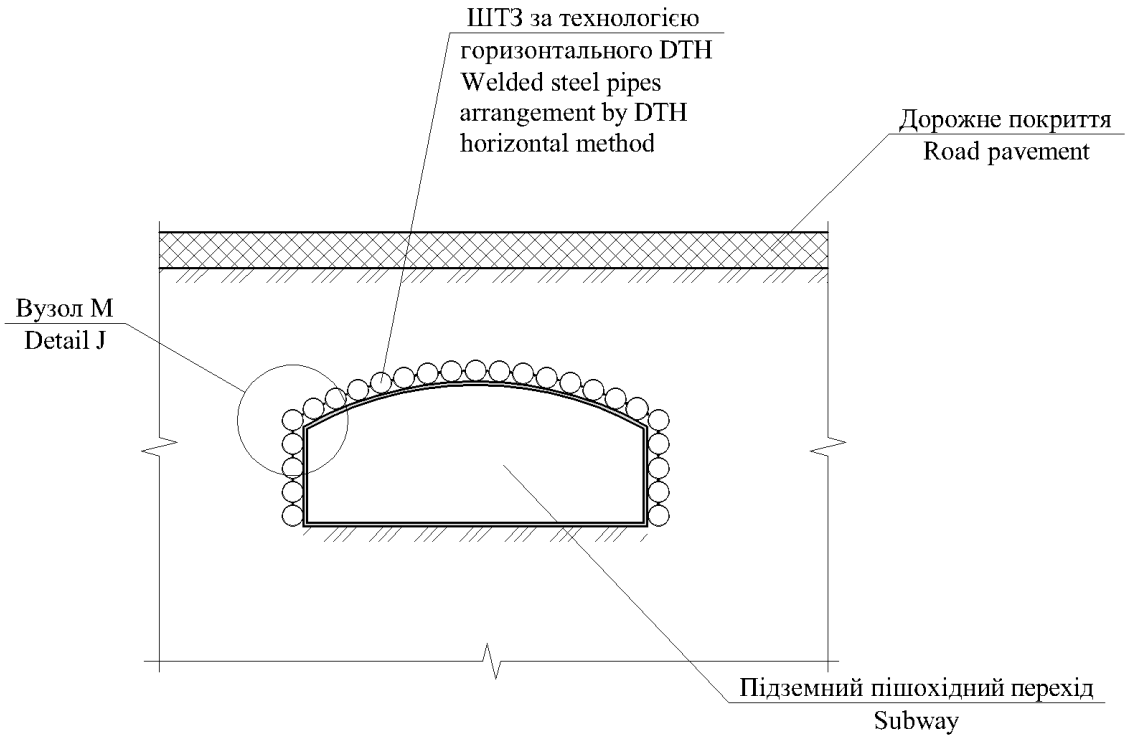


Fig. 4.11 Example of steel pipe piles and H-beam sheet piles application in construction of retaining walls



Detail J

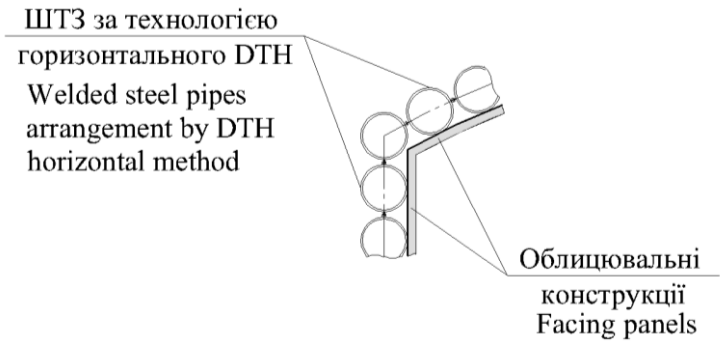


Fig. 4.12 Example of steel pipe piles application in construction of subway by DTH horizontal method

5 USED MATERIALS

5.1 Pipes and beams used in the manufacture of sheet piles walls made of steel pipe piles (ШТЗ) and H-beam sheet piles (ШБЗ) should be made of rolled steel (sheet, profile, broad-strip universal, long steel), or low carbon and low-alloy steel pipes. General-purpose rolled steel, rolled steel for welded structures and hot-rolled steel can be used.

5.2 Steels are divided into the following three grades according to their corrosive resistance:

I grade – steel of normal corrosion resistance, namely carbon steel according to the Standards ДСТУ 8539:2015 (grade С235 and other), ДСТУ 4484/ГОСТ 535, ДСТУ 8803:2018 (Ст3пс5 grade steel and other), ДСТУ EN10025-2 (S235JR grade steel and other), as well as low-alloy steel according to the Standards ДСТУ 8539:2015 (С345 grade and other), ДСТУ 8541:2015 (09Г2С grade steel and other), ДСТУ EN10025-3 (S355 grade and other), and ДСТУ EN10025-4 (S460M grade steel).

II grade – steel of high corrosion resistance according to the Standard ДСТУ 8541:2015 (09Г2Д grade steel and other), mass fraction of copper 0,15-0,30 %.

III grade – steel of high resistance to atmospheric corrosion according to the Standard ДСТУ 8541:2015 (10ХНДП grade steel and other).

5.3 The main physical properties of materials for structures should be taken in accordance with Annex Б of the Standard ДБН В.2.6-198:2014.

5.4 Rolled sheet steel, profiled steel and broad-strip universal steel is divided as follows:

– rolled steel of normal strength, carbon, characteristic resistance of rolled steel is R_{yn}< 290 N/mm^2, varying in accordance with the degree of deoxidation into unkilled, balanced and killed, and satisfying the following requirements (according to mass factor of element): carbon content should not exceed 0.22%, sulfur content - 0.05 %, and phosphorus content - 0.04 %; the relative elongation of round samples with a working length equal to five sample diameters should not be less than 18 %, excluding limiting deviations;

– rolled steel of high strength, as a rule low-alloy, characteristic resistance of rolled steel is 290 N/mm^2≤R_{yn}≤ 390 N/mm^2 with thickness of up to 50 mm, the relative elongation of round samples with a working length equal to five sample diameters – not less than 18 %;

– rolled steel of high strength, as a rule of heat treated or thermomechanically rolled steel, characteristic resistance of rolled steel is 390 N/mm^2<R_{yn}≤ 590 N/mm^2, the temporary elongation of round samples with a working length equal to five sample diameters – not less than 16%;

– rolled steel shall satisfy the requirements of impact resistance according to Annex B of the Standard ДБН В.2.6-198:2014.

5.5 Requirements to rolled steel application are given in the Annex Г of the Standard ДБН В.2.6-198:2014 (Table Г.1).

5.6 Requirements to carbon, phosphor and sulphur content in steels for building structures and recommendations for values of carbon equivalent are given in the Annex B of the Standard ДБН В.2.6-198:2014. If mechanical properties of rolled steel are comparable, preference should be given to application of rolled steel with lower carbon equivalent values for the manufacture of welded structures.

5.7 Rolled sheet steel of 25 mm and more thickness for through-thickness operated elements, as well as rolled steel of 40 mm and more thickness in welded joints, depending on the structure group, should meet the following requirements:

– for the 1st group of structures – to be of 0 continuity class according to Standard ДСТУ 8818:2018, and quality group not less than Z35 according to Standard ГОСТ 28870;

– for the 2nd group of structures – to be of continuity class not more than 1 according to Standard ДСТУ 8818:2018, quality group not less than Z25 according to Standard ГОСТ 28870;

– for the 3rd and 4th group of structures – to be of continuity class not more than 2 according to Standard ДСТУ 8818:2018, quality group not less than Z15 according to Standard ГОСТ 28870.

– When choosing steel for structures, it should be considered the following:

– importance category of a structure according to the Standard ДБН В.1.2-14;

– purpose of a structure and its elements and their importance category according to the Standard ДБН В.1.2-14;

– possible consequences of reaching the limit states;

– nature of the stresses (static, dynamic) and their level;

– type of stress (uniaxial, plane or volumetric, tension or compression);

– availability of welded joints (level of residual stress, degree of stress concentration, properties of steel in welding area);

– degree of the impacts aggressiveness;

– thickness of rolled steel;

– peculiarities of design shape and manufacture technology (stress-risers, guillotine cutting, hardening, etc.).

5.8 Depending on the factors given in the paragraph 5.7, in accordance with paragraph 5.6 and taking into account the categories of structures in accordance with paragraph 5.3.5 of the

Standard DBN B.2.6-198:2014, structures and elements are divided into four groups according to the table A.1 of the Standard ДБН В.2.6-198:2014.

5.9 When choosing steel, the architectural construction climate region of a construction site and the design temperature of operation should be accepted in accordance with the Standard ДСТУ-Н Б В.1.1-27.

5.10 The minimum design temperature should be taken as the temperature of the coldest five-day period in the construction area in accordance with Standard ДСТУ-Н Б В.1.1-27 with 0.98 probability for structures operated in unheated premises and at outdoor temperatures.

5.11 Steels for groups of structures should be chosen in accordance with Annex Г of the Standard ДБН В.2.6-198:2014. The design of structures, except for the use of high-strength steels, is recommended to be made of S355J2 steel, which, with sufficient strength, is very easy to process and weld.

5.12 Pipes are used according to the following classification parameters: by type; by steel grade according to ДСТУ or EN Stanards; by diameter and wall thickness, and by other pipe parameters that may be used in design.

5.13 The following types of pipes are used: longitudinal welded pipes or weldless drawn pipes. The other pipe types may be permitted for use upon appropriate feasibility study, depending on soil conditions, equipment of a contractor, mastery of the proposed construction technology, and other influencing factors. The pipes may be used only after their test driving, including preparation of a relevant report. The test driving shall be carried out by the mechanisms used for the main works.

5.14 Pipes of the following steel grades may be used.

5.15 In accordance with ДСТУ Standards

– К38 grade (yield strength accepted by product standards $\sigma_т$ = 235 N/mm2 (24 kgf/ mm2); temporary tensile strength, accepted according to product standards $\sigma_в$ = 372 N/mm2 (38 kgf/mm2); minimum relative elongation δ5%= 20%);

– К50 grade (yield strength accepted by product standards $\sigma_т$ = 343 N/mm2 (35 kgf/mm2); temporary tensile strength, accepted according to product standards $\sigma_в$ = 485 N/mm2 (50 kgf/mm2); minimum relative elongation δ5%= 20%);

– К52 grade (yield strength accepted by product standards $\sigma_т$ = 353 N/mm2 (36 kgf/mm2); temporary tensile strength, accepted according to product standards $\sigma_в$ = 510 N/mm2 (52 kgf/mm2); minimum relative elongation δ5%= 20%);.

5.16 In accordance with EN

– S355J2 (yield strength accepted by product standards R_{eh} = 345 MPa; temporary tensile strength, accepted according to product standards $R_м$ = 470 MPa; minimum relative elongation δ= 22%);

– S460MH (yield strength accepted by product standards R_{eh} = 440 MPa; temporary tensile strength, accepted according to product standards $R_м$ = 530-720 MPa; minimum relative elongation δ= 17%);

– X60 (yield strength accepted by product standards R_{eh} = 415 MPa; temporary tensile strength, accepted according to product standards $R_м$ = 520 MPa; minimum relative elongation δ= 18%);

– X65 (yield strength accepted by product standards R_{eh} = 450 MPa; temporary tensile strength, accepted according to product standards $R_м$ = 535 MPa; minimum relative elongation δ= 18%);

– X70 (yield strength accepted by product standards Reh = 485 MPa; temporary tensile strength, accepted according to product standards $R_м$ = 570 MPa; minimum relative elongation δ= 18%);

– X80 (yield strength accepted by product standards Reh = 555 MPa; temporary tensile strength, accepted according to product standards $R_м$ = 625 MPa; minimum relative elongation δ= 18%).

5.17 Pipes of the other steel grades can be used upon an appropriate feasibility study, taking into account the type of pipes, their physical, chemical and mechanical characteristics, and the operational conditions of the structure. If required, a test driving of piles should also be performed.

5.18 Pipes with diameter from 800 mm to 2500 mm and wall thickness from 10 mm to 26 mm can be used according to the pipe grades. With the appropriate pile driving equipment, pipes of diameter over 2500 mm and wall thickness over 26 mm can be used.

5.19 For temporary structures and auxiliary facilities, pipes of wall thickness less than 10 mm are allowed, provided that the appropriate strength and stability are ensured. For permanent structures and main facilities, pipes of wall thickness less than 10 mm may be used, provided that additional measures are taken to ensure the durability of the structure and its strength and stability.

5.20 The list of parameters controlled in the manufacture of pipes should be adopted in accordance with the Standard ДСТУ 8943:2019.

5.21 Additional requirements to pipe piles for certain types of structures should be adopted in accordance with the relevant Standards ДБН or ДСТУ, and other regulatory documents governing their use.

5.22 Depending upon the design features, additional requirements for other pipe parameters may be imposed while designing.

5.23 Each batch of pipes with a total weight of up to 100 tons must have a certificate containing the results of physical, chemical and mechanical tests, the date of which does not exceed 12 months from the date of the pipes purchase.

5.24 The following sheet pile interlocking systems are used:

– MF 63 (a couple length – 63 mm, weigh of 1 m of a couple – 15,46 kg/m, steel S355J2, maximum tensile strength 2552 kN/m);

– MF 75; (a couple length – 75 mm, weigh of 1 m of a couple – 19,04 kg/m, steel S355J2, maximum tensile strength 3419 kN/m);

– MF 100; (a couple length – 100 mm, weigh of 1 m of a couple – 21,18 kg/m, steel S355J2, maximum tensile strength 3419 kN/m);

– MF 130; (a couple length – 130 mm, weigh of 1 m of a couple – 24,04 kg/m, steel S355J2, maximum tensile strength 3419 kN/m);

– MF 180 a; (a couple length – 180 mm, weigh of 1 m of a couple – 29.05 kg/m, steel S355J2, maximum tensile strength 3419 kN/m);

– MF 180 b; (a couple length – 180 mm, weigh of 1 m of a couple – 28.18 kg/m, steel S355J2, maximum tensile strength 2558 kN/m);

– MF 230; (a couple length – 230 mm, weigh of 1 m of a couple – 33,19 kg/m, steel S355J2, maximum tensile strength 2558 kN/m);

– MF 64 (a couple length – 64 mm, weigh of 1 m of a couple – 17,70 kg/m, steel S355J2, maximum tensile strength 3419 kN/m);

– MF 64-IC (a couple length – 64 mm, weigh of 1 m of a couple – 16,97 kg/m, steel S355J2, maximum tensile strength 3164 kN/m);

– FD180 (a couple length – 180 mm, маса 1 м – 34,84 kg/m, steel S355J2, maximum tensile strength 5843 kN/m);

– FD300 (a couple length – 300 mm, маса 1 м– 42,8 kg/m, steel S355J2, maximum tensile strength 6312 kN/m);

– LPB100-10 (a couple length – 100 mm, weigh of 1 m of a couple – 19,72 kg/m, steel S355J2, maximum tensile strength 980 kN/m);

– LPB180-10 (a couple length – 180 mm, weigh of 1 m of a couple – 25,68 kg/m, steel S355J2, maximum tensile strength 1026 kN/m);

– LPB180-12 (a couple length – 180 mm, weigh of 1 m of a couple – 29,0 kg/m, steel S355J2, maximum tensile strength 1502 kN/m);

– LPB180-16 (a couple length – 180 mm, weigh of 1 m of a couple – 44,8 kg/m, steel

S355J2, maximum tensile strength 1828 kN/m);

– LPB248-12 (a couple length – 248 mm, weigh of 1 m of a couple – 36,52 kg/m, steel S355J2, maximum tensile strength 1500 kN/m);

– LPB300-16 (a couple length – 300 mm, weigh of 1 m of a couple – 59,3 kg/m, steel S355J2, maximum tensile strength 1828 kN/m);

– if reqired, the use of other types of sheet pile interlocking systems is allowed.

The general view of the interlocking systems is shown in Fig. 5.1 and Fig. 5.2.

5.25 Rolled or welded H-beams are used for the manufacture of H-beam sheet piles (ШБ3). The rolled beams grades are in Attachment 9.5. The welded beams grades are in Attachment 9.6. The use of H-beams according to the other grades is permitted provided that they meet the requirements specified in this document.

5.26 For structures made of profile, sheet, broad-strip universal rolled steel in accordance with the Standards DSTU 8539:2015, DSTU 8803:2018; DSTU 4484/GOST535, DSTU EN10025-2, DSTU EN10025-3, DSTU EN10025-4, DSTU EN10025-6 and other applicable regulatory documents [1]-[6], listed in Annex Ш of the Standard DBN B.2 .6-198:2014, long steel in accordance with the Standards DSTU 8541:2015 and DSTU 4484/GOST 535, electric-welded pipes in accordance with the Standard DSTU 8943:2019, hot-rolled pipes in accordance with the Standard DSTU 8938:2019, as a rule, steels should be used in accordance with Annex Г of the Standard ДБН В.2.6-198:2014.

5.27 For welded joints of steel structure elements electrodes for manual arc welding, welding wire, fluxing agents, flux-cored wire, carbon dioxide, or argon should be used in accordance with Annex Д of the Standard ДБН В.2.6-198:2014.

5.28 The welding materials and welding technology used must ensure that tensile strength of the weld metal be not lower than the characteristic value of tensile strength R_{un} of basemetal, impact strength and relative elongation depend on the requirements for the material of specific structures.

5.29 Additional waterproofing of sheet pile interlocking systems is performed if necessary, or as required by the design. For waterproofing, Steelant-B to be used, which should be applied hot to the sheet piles interlocking systems according to the manufacturer's instructions.

5.30 Need for corrosion protection of the sheet piles walls made of steel pipe piles (ШБ3) and H-beam sheet piles (ШТ3) and detection of protection areas are determined by the design. Corrosion protection shall be performed in accordance with the requirements of EN 12944, depending on the expected service life of the coating and the types of: structures, surface preparation, environment, protective painting system, and operation (new or repeated).

5.31 Rolled steel and steel products manufactured in accordance with other regulatory documents may also be used if their properties meet the requirements for impact strength and chemical composition in accordance with Annex B of the Standard ДБН В.2.6-198:2014, and the use of materials for connecting steel structures in accordance with Annex Д of the Standard ДБН В.2.6-198:2014.

5.32 Design characteristics of materials shall be taken in accordance with Article 7 of the Standard ДБН В.2.6-198:2014.

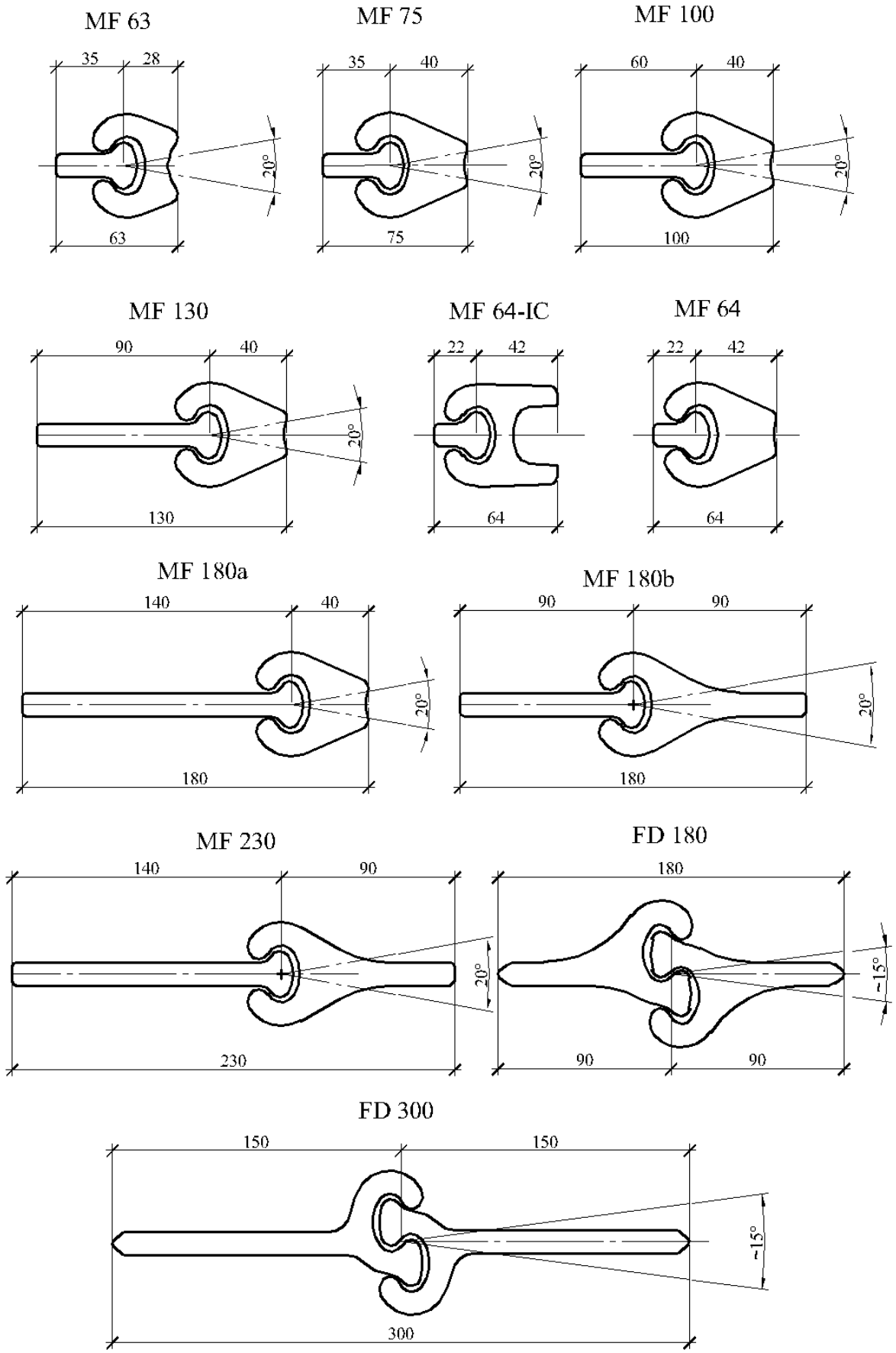


Fig. 5.1 General view of MF, FD type locks

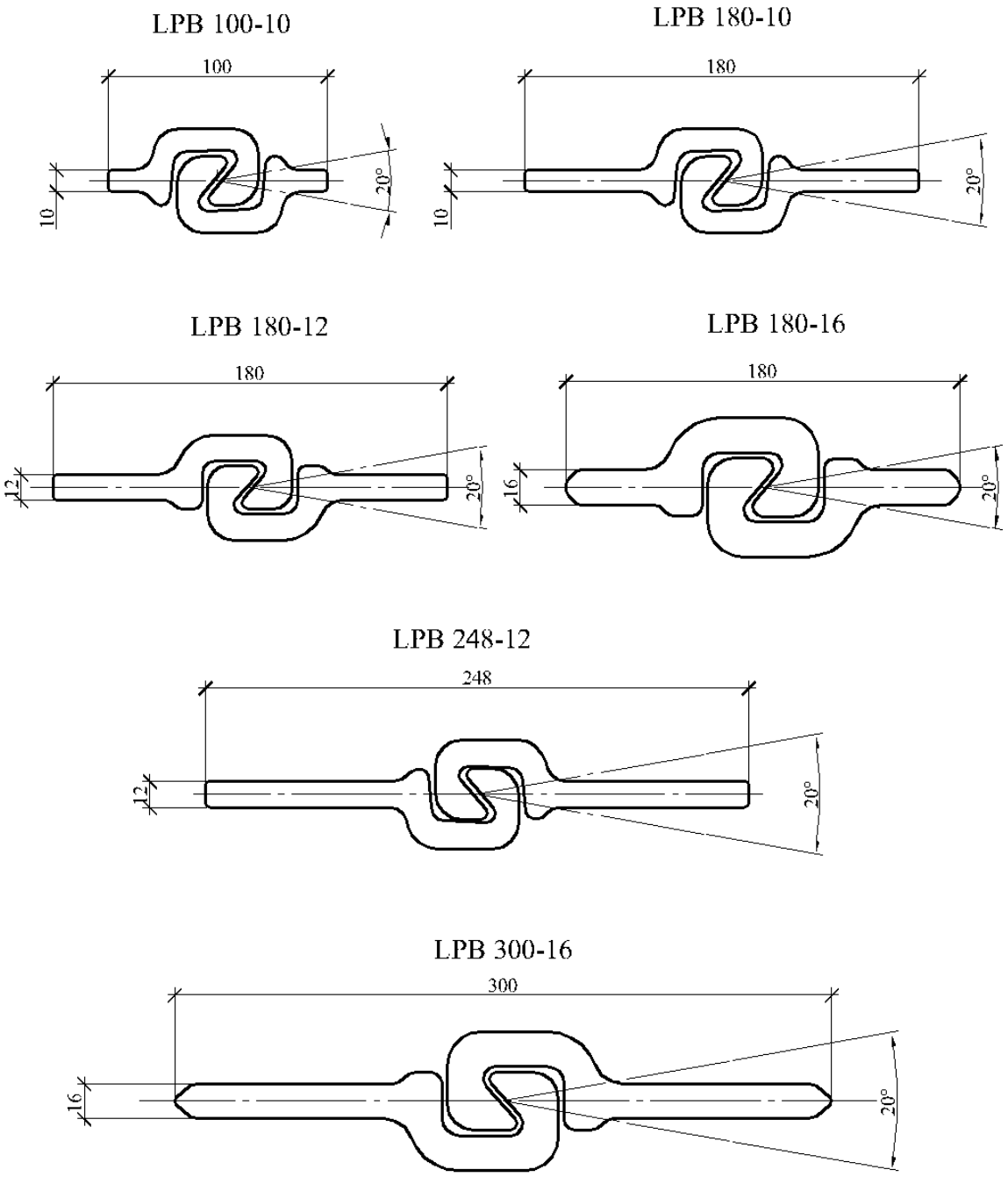


Fig. 5.2 General view of LPB type locks

6 DESIGN PARAMETERS FOR SHEET PILES WALLS MADE OF STEEL PIPE PILES AND H-BEAM SHEET PILES

Definition of the following design parameters:

6.1 Weight of 1 sq.m of combination

6.2 Moment of inertia

6.3 Section modulus

6.4 Pitch of the main bearing elements

The moments of inertia and the sections modulus of the combinations been designed, are given per one linear meter.

The design parameters are summarized in tables. The tables are presented separately according to pipe range (See Attachments 9.1-9.4).

The same is for hot rolled and welded H-beam elements (See Attachments 9.5-9.6).

7 DESIGN OF STRUCTURES APPLYING SHEET PILES WALLS MADE OF STEEL PIPE PILES (ШТ3) AND H-BEAM SHEET PILES (ШБ3)

Choosing construction of a structure

7.1 The type of a structure should be chosen in view of natural conditions of a construction area, technological requirements, the size of construction site, possible methods of doing work, geological conditions, environmental requirements, etc.

7.2 The design of a structure should be chosen on the basis of the technical and economic appropriateness of its use in specific construction conditions by comparing options.

7.3 Economic appropriateness of the compared options should be determined by matching the construction costs. In case the construction schedules according to the options are drastically different, the economic effect obtained as a result of earlier commissioning of the designed facility should be taken into account.

7.4 When choosing an alternative design, it should be considered the following:

– consumption of main construction materials;

– availability of local construction materials;

– labor intensity of the work;

– level of construction complexity;

– availability of equipment and mechanisms required for the construction;

– availability of human power;

– requirements for structures durability;

– operational indices.

7.5 When developing alternative designs, the following structures should be preferred:

a) with fewer pile rows due to increased strength and/or stiffness of the main pile row;

– with the least amount of underwater technical works.

7.6 Development of new structures should be focused on the advanced methods of construction technology.

General provisions of calculating structures

7.7 Structures as well as their structural elements and foundations should be calculated using the method of boundary states. There are two groups of boundary states. The first group of boundary states (per loss of bearing capacity or completely inoperative structures or foundations) - calculations of strength, stability and endurance; the second group of boundary states (complicating the normal operation of structures or foundations) - calculations of deformations

due to settlements, deflections, rolls, horizontal displacements, and calculations of crack formation or opening.

7.8 The load-bearing structures should be calculated for loads acting during their construction, operation and repair.

In calculations the following condition should be observed to prevent the boundary states:

$$\gamma_{lc} F \leq \frac{\gamma_c}{\gamma_п} R, \tag{7.1}$$

where γ_{lc} is coefficient of load combinations, which is taken in accordance with the standards;

F is design value of generalized force effect (force, moment, stress), deformation or other parameter that is used to assess the boundary state;

R is design value of the generalized bearing capacity, deformation or other parameter established by design standards;

γ_c is a coefficient of working conditions, which is taken in accordance with the standards;

$\gamma_п$ is a safety factor of the structure purpose, which is taken in accordance with the standards.

7.9 When designing structures, the design values of current operating loads determined by multiplying the characteristic value of load by corresponding load safety factor γf, should be taken.

Additional requirements to hydroengineering structures calculation

7.10 Hydroengineering structures, their constructions and foundations according to the second group boundary states should be calculated using a load safety factor γ_f , as well as safety factors for materials γ_m and soils γ_g equal to 1.0, except for cases stated in the standards for design of certain types of hydroengineering structures, their constructions and foundations.

7.11 When designing marine berthing structures, the design values of soil characteristics φ and C should be obtained; for the first group boundary states φ_I and C_I , for the second group boundary states φ_{II} and C_{II} (φ is the angle of internal friction of soil; C is cohesion). These characteristics are taken from the data of engineering and geological surveys and soil tests fulfilled in accordance with the requirements of the standards for hydroengineering structures design.

7.12 Calculating other structures (bridges, roads, etc.) have additional requirements, which should be taken into account in accordance with the relevant standards.

7.13 When calculating in accordance with European standards, compilation with Ukrainian standards is not allowed.

Loadings and impacts

7.14 Loads and impacts are divided into main and episodic depending on the reasons for their occurrence. Depending on the variability in time, impacts are divided into constant and variable. Depending on the time of continuous action, variable loads and impacts are divided into long-term, short-term and episodic. Loads occurred during the manufacture, storage and transportation of structures, as well as during their construction, should be considered in the calculations as short-term. The basis for assigning loads is their characteristic values.

Depending on the nature of loads and the purpose of calculation, four types of design values are used: limit, operational, cyclic, and quasi-permanent. These types of loads should be applied in accordance with Table 4.1 of the Standard ДБН В1.2:2006.

Constant loads include: weight of the structural elements; weight of permanent technological equipment not changing its placement during operation; weight of soil; lateral soil pressure taking into account the permanent loads located on its surface; load from the prestress of structure.

Variable long-term loads and impacts include: loads from handling equipment and transport, and stored cargo, as well as other loads connected with the structure operation: lateral soil pressure from temporary loads on the territory of the structure; filtration pressure of water (including hydrostatic) during normal operation of drainage equipment; effects of irregular deformations of the foundation without changes in soil structure; effects of settlement and creep of materials and soil foundation.

Variable short-term loads and impacts include: loads acting during the construction period; thermal and climatic effects; wave, ice and ship loads (for hydroengineering structures).

Episodic loads and impacts include:

- additional filtration pressure of water in case normal operation of anti-filtration and drainage equipment is disrupted;
- seismic loads;
- dynamic loads from explosions;
- impact of irregular deformations of foundation with changes in the soil structure;
- hydrodynamic and suspension effects caused by rare hydrometeorological events.

7.15 Calculation of structures requires using two types of combination - main and emergency.

To verify the first group boundary states, the main combinations are used, they include constant loads with limiting design values, and limiting design, cyclic or quasi-constant values of variable loads.

To verify the second group limit states, the main combinations are used, they include constant loads with operational design values, as well as operational design, cyclic or quasi-constant values of variable loads. In addition to constant and variable loads, the emergency combination may include only one episodic impact.

Load combinations are formed as a set of their design values or corresponding forces and/or displacements used to test a structure or foundation in a certain boundary state and in a certain design situation. It is assumed that all loads in the selected combination affect simultaneously the object of calculation.

Loads and impacts should be taken in conditions to be the most unfavorable but realistic for a considered combination, separately for the construction and operational periods, and the design case of repair.

The combination of loads during construction and repair periods should be assigned in view of the accepted procedure for work execution.

When calculating episodic loads, the requirements of standards for construction of earthquake-resistant structures should be taken into account.

Any temporary load should not be included in the combination if it improves the boundary state under consideration.

7.16 The weight of structural elements is determined by their geometric dimensions and specific gravity of materials, considering moisture content.

7.17 The weight of soil is determined by the thickness of the layer and specific gravity of the soil, considering moisture content.

The specific gravity of soil, depending on its location and moisture content, is determined as follows: above the design water level in natural moisture state - according to engineering and geological surveys; under water - taking into account the full suspension according to the formula

$$\gamma_{\text{взв}} = \frac{\gamma_s - \gamma_w}{1 - e}, \tag{7.2}$$

where γ_s is specific weight of soil particles, kN/m^3 ;

γ_w is specific weight of water, kN/m^3;

e is porosity coefficient in the natural state.

If justified, partial suspension in the area below the bottom level may be allowed for clay soils of limited moisture content in case there are no filter layers and lenses. The weight of soil of cavities backfill, as well as stone, crushed stone or gravel bed is determined depending on the specified density and moisture content.

7.18 The soil pressure is assumed to be effective at the design plane.

Position of design plane depends on the spacing and dimensions of pile elements.

7.19 Loads within the territory of a structure are usually assigned in the design specification. In case the appropriate data are not available in the design specification, they can be determined during the design process, taking into account requirements of the technological standards for relevant structures.

Wheel loads (railway, etc.) should be assumed as uniformly distributed in two directions (along the length and width of support elements). For spacer structures, the concentrated load may be replaced by an equivalent uniformly distributed load q_e. The determination of q_e is carried out taking into account requirements of standards for the relevant structures.

7.20 Load epure of filtration pressure of water is determined by plotting depending on the type of structure (Fig. 7.1).

The maximum ordinate p of the load epure is determined by the formula

$$p_{\phi} = \gamma_w \Delta h, \tag{7.3}$$

where γ_w is the specific gravity of water, kN/m3 ;

Δh is the difference in levels behind the structure and before the structure, m.

Zero ordinate of the load epure for sheet pile walls is assumed to be at the level of the wall foot.

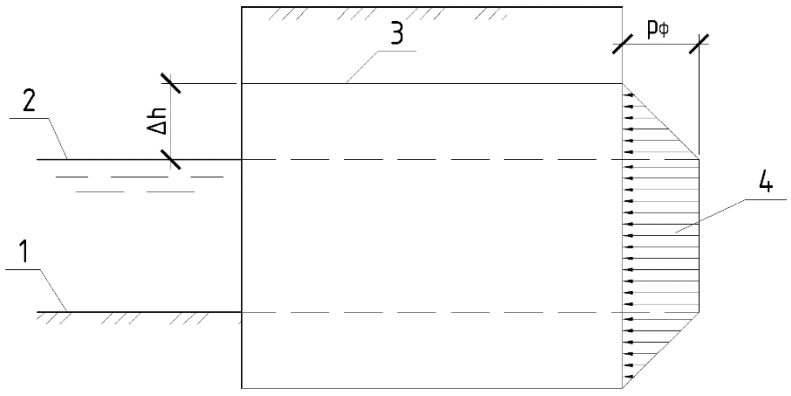


Fig. 7.1. Symbols: 1 – design bottom; 2 – minimum water level; 3 – backwater level; 4 – epure of water filtration pressure

Water filtration pressure should not be considered in case of installing drainage devices that exclude the backwater, or for structures on a stone or rubble bed. If there is a significant and intense lowering of water level within a port water area and low permeability of foundation, the weight of soil in the lowering zone should be accepted as specific gravity of soil with water-filled pores.

7.21 Impact of irregular deformations should be considered when choosing the design model in accordance with the guidelines for certain type structures design.

7.22 Shrinkage and creep of concrete should be considered in accordance with the requirements of the Standard СНиП 2.06.08-87.

7.23 Wave loads should be determined in accordance with the requirements of the Standard СНиП 2.06.04-82*.

Wave loads should be considered in case the height of outgoing wave near the structure exceeds 1 m. In this case, the wave pressure intensity (interfering, sliding, oblique wave) of the wave trough approaching to the wall, considering the rate of level fluctuation behind the structure, may be determined with a reduction factor of 0.5.

7.24 Designing structures under ice loads should include the following design cases:

- from ice fields;
- from continuous ice cover under its thermal expansion;
- from ice cover frozen to structure due to the water level changes.

Ice loads should be determined in accordance with the requirements of the Standard СНиП 2.06.04-82*.

It is allowed to consider the load from ice cover frozen to structure due to the water level changes in the calculation of structures with a solid front surface only in particularly severe weather conditions with special justification.

7.25 The load from ships should be determined in accordance with the requirements of the Standard СНиП 2.06.04-82*.

The following should also be considered:

- load from the vessel approaching to the structure;
- load from berthing impact of the moored vessel;
- load from tension of the mooring lines.

7.26 Loads acting during the construction period should be determined on a case-by-case basis, depending on the methods and sequence of jobs, types of machines and equipment involved, etc.

7.27 Loads caused by temperature changes should be considered in calculating elements of structures constructed in particularly severe weather conditions.

Average temperatures change and difference in warm and cold seasons for structural elements should be determined on the basis of thermotechnical analyze in accordance with the relevant standards.

7.28 Seismic loads should be determined in accordance with the requirements of the Standard ДБН В.1.1.12:2014.

7.29 The design load value is determined by multiplying the characteristic load value by the corresponding load safety factor γ_f.

When calculating in accordance with the first group boundary states, the value of load safety factor γ_f.should be taken in accordance with Annex I to the Standard ДБН В.2.4-3:2010 (for hydroengineering structures) and the relevant clauses of standards governing the other structures design.

In calculations according to the second group boundary states, the values of load safety factors γ_f are assumed to be equal to 1,0.

The load safety factors γ_f assumed to be the same for both the acting load and its projections (components), regardless that one of them is included in the generalized force action, and the other - in the boundary resistance force.

When calculating the overall stability by depth shear and assuming circular cylindrical and flat (broken) sliding surfaces, load safety factors are allowed to be equal to 1,0.

7.30 Dead weight of concrete and reinforced concrete elements shall be multiplied by the dynamic factor determined in accordance with the Standards ДБН В.2.6-98:2009, ДБН В.2.1-10:2009 and ДСТУ Б.В. 2.1-27:2010 in case of finding out forces arising from their lifting, transportation and installation, with this taking the load safety factor equal to 1.0.

7.31 Cross-sections of steel structural elements should be calculated in accordance with the requirements of the Standard ДБН В.2.6-198:2014.

7.32 Concrete and reinforced concrete structures and elements should be calculated in accordance with the Standards СНиП 2.06.08-87 and ДБН В.2.6-98:2009.

Determination of lateral soil pressure

7.33 Intensity of the horizontal component of the active soil pressure in case of a flat soil surface is determined by the following formula

$$p_a = p_{a,\text{rp}} + p_{a.q,}, \tag{7.4}$$

where $p_{a,rp}$ is intensity of the horizontal component of the active pressure from soil weight, kPa, determined in accordance with the paragraph 7.34;

$p_{a,q}$ is intensity of the horizontal component of the active pressure from the uniformly distributed loads acting on the territory, kPa, determined in accordance with the paragraph 7.37;

7.34 Intensity of the horizontal component of the active pressure from soil weight $p_{a,\text{rp}}$ is determined by the following formula

$$p_{a,\text{rp}} = q_z\lambda - c\lambda_{\text{ac}}, \tag{7.5}$$

where q_z is intensity of vertical soil pressure, kPa, determined in accordance with the paragraph 7.35;

λ_a is a coefficient of horizontal component of active soil pressure, determined in accordance with the paragraph 7.36;

c ia specific soil cohesion, kPa;

λ_{ac} is a coefficient of horizontal component of active soil pressure from cohesion forces, determined in accordance with the paragraph 7.36.

Note. In cases where $c\lambda_{ac}$ is greater than $q_z\lambda_a$,, the value of $p_{a,zp}$ in this area is assumed to be zero.

7.35 Intensity of the vertical soil pressure q_z is determined by the following formula

$$q_z = \gamma_i\left(z - \sum_1^{i-1} h\right) + q_{zi-1)}, \qquad (7.6)$$

where i is a sequence number of the soil layer with the same physical and mechanical characteristics within the wall height;

γ_i is specific gravity of the i-th soil layer, kN/m^3;

z is a current coordinate along the wall height, m;

h_i is height of the i-th layer, m;

q_{zi} is intensity of vertical soil pressure of the overlying layers, kPa

7.36 Coefficients of horizontal component of the active soil pressure λ_a and λ_{ac} are recommended to be determined in accordance with the requirements of the Standard СНиП 2.06.07-87.

where φ is the angle of internal friction of the soil, degrees;

α is the angle of inclination of the design plane of the wall to the vertical, degrees, which is taken with a minus sign when the wall is inclined to the ground;

ρ is the angle of inclination of the soil surface to the horizontal, degrees, which is taken with a plus sign in case of raising the territory mark level;

δ is the angle of friction of the soil along the design plane, degrees, which is assumed to be not more than 0.667φ for the design plane that passes through the contact of soil and structure, or

$\delta = \varphi$ if the plane passes in the soil, but not more than 30°

7.37 Intensity of the horizontal component of the active pressure p_{aq} from uniformly distributed loads of q_j intensity spread over the territory, is determined as follows:

in case of infinite load across strip width ($b_q = \infty$) placed directly behind the design plane,

$$p_{a.q} = mq\lambda_a, \qquad (7.7)$$

where

$$m = \frac{1}{1 + \tan\alpha \tan\rho}, \tag{7.8}$$

in case of infinite load across strip width ($b_q = \infty$) placed at the distance a_q from the design plane,

$$p_{a.q} = mq\lambda_a(1 - k_{q.1}), \tag{7.9}$$

where

$$k_{q.1} = \frac{2}{\mathrm{p}}\left(\beta_1 - \frac{\sin 4\beta_1}{4}\right), \tag{7.10}$$

$$\beta_1 = \tan^{-1}\frac{z}{a_q}, \text{radian}, \tag{7.11}$$

z is a current coordinate along the wall height, m;

in case a load strip has width b_q , placed directly behind the design plane,

$$p_{a.q} = mq\lambda_{ak}q_2, \tag{7.12}$$

where

$$k_{q.2} = \frac{2}{\pi}\left(\beta_2 - \frac{\sin 4\beta_2}{4}\right), \tag{7.13}$$

$$\beta_2 = \tan^{-1}\frac{z}{b_q}, \text{radian}, \tag{7.14}$$

in case a load strip has width b_q , placed at the distance a_q from the design plane,

$$p_{a,q} = mq\lambda_a\left(k_{q2} - k_{q1}\right), \tag{7.15}$$

where $k_{q,2}$, $k_{q,1}$ are determined above.

Values $k_{q,i}$ are accepted depending on the value $cot\ \beta_i$

$$\cot\beta_1 = \frac{z}{a_q}, \tag{7.16}$$

$$\cot\beta_2 = \frac{z}{a_q + b_q}, \tag{7.17}$$

7.38 In case a rock backing is available, the active soil pressure, which is determined under the assumption of infinite extension of soil layers, including stone (see paragraph 7.33), is supplemented by the pressure from the loading of soil located in a sliding triangle on the slope of the rock backing (Fig. 7.2).

Intensity of the horizontal component of additional pressure Δ from soil surcharge should be determined in accordance with the following formulas:

within the rock backing at a heigh of Δh

$$\Delta p_a = \frac{q_p(\lambda_a - \lambda_{a.k})a_{h.1}}{\Delta h_k}, \tag{7.18}$$

below the rock backing at a depth of Δd,

$$\Delta p_a = \frac{q_p(\lambda_a - \lambda_{a.k})a_h}{\Delta d}, \tag{7.19}$$

where q_p is intensity of vertical soil pressure taking into account uniformly distributed loads across the territory at the level of intersection of the rock backing slope with a fall plane, drawn from a point on the design plane, in which the soil pressure Δp_a, kPa, is determined (paragraph 7.35);

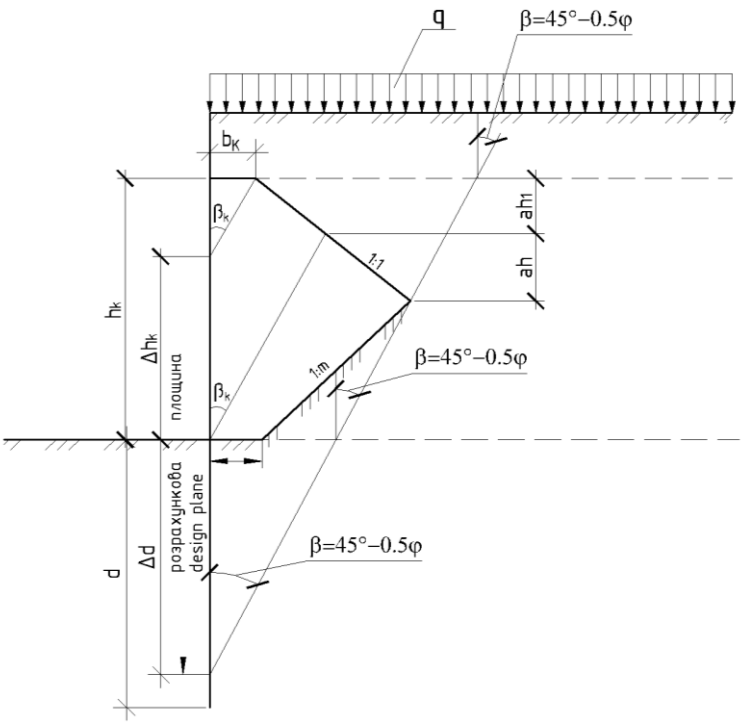


Fig. 7.2

7.39 Intensity of the vertical component of active soil pressure p_{av} is determined according to the formula

$$p_{a.v} = p_a \tan(\alpha + \delta), \tag{7.20}$$

where p_a is intensity of horizontal component of active soil pressure, kPa.

7.40 The horizontal E_a and vertical E_{av} components of active soil pressure are determined by the area of the soil pressure intensity epures.

7.41 The intensity of the horizontal component of the soil silo pressure between the walls is determined according to the formula

$$p_{a.сил} = q_{z,сил}\lambda_a - \frac{c}{\tan\varphi}[1 - \lambda_a(1 - m_{сил})], \tag{7.21}$$

where $q_{z.сил}$ is intensity of vertical soil pressure between the walls, kPa, which determined according to the paragraph 7.42;

λ_a is the coefficient of the horizontal component of active soil pressure, which is taken according to the paragraph 7.36;

$$m_{\text{сил}} = 1 - e^{\frac{z-\sum_1^{i-1} h_i}{h_0}}, \tag{7.22}$$

where z is a current coordinate by wall height, m;

h_i is height of an i-th soil layer, m;

h_0 is a value, m, determined for each i-th soil layer by the formula (7.23 or 7.24).

For a planar problem

$$h_0 = \frac{a}{2\lambda_a \tan\delta}\ , \tag{7.23}$$

where a is a distance between design planes of the walls, m;

δ is an angle of soil and wall friction, degrees (see. paragraph 7.36);

for cellular (shell) structures,

$$h_0 = \frac{A}{u\lambda_a \tan\delta}\ , \tag{7.24}$$

where A is a cell area, m^2;

u is a cell perimeter, m.

Note. In case, if $\frac{c}{tan\,\varphi}[1 - \lambda_a(1 - m_{\text{сил}})]$ ***is more than q*** $_{zi-1}$ ***, force value*** $p_{a,\text{сил}}$ ***at that sector should be taken equal to 0.***

7.42 Intensity of vertical soil pressure between the walls is determined in accordance with the formula

$$q_{z.\text{сил}} = \gamma_i m_{\text{сил}} h_0 = q_{zi-1,\text{сил}}(1 - m_{\text{сил}}), \tag{7.25}$$

where $q_{zi-1,\text{сил}}$ is intensity of the vertical soil pressure between the walls on the surface of the i-th layer, taking into account the uniformly distributed load on the soil surface between the walls to have intensity q_0, kPa,

$$q_0 = \frac{\sum(q_j b_j + F_j)}{a}, \tag{7.26}$$

where q_j is intensity of the uniformly distributed load, spread within a, kPa;

b_j is a load strip with q_j, m;

F_j is a concentrated loads within a, kN/m.

7.43 Intensity of the vertical component of soil silo pressure between the walls is determined according to the formula

$$p_{a.v,\text{сил}} = p_{a.\text{сил}} \tan\delta\,, \tag{7.27}$$

where $p_{\text{a,сил}}$ is intensity of the horizontal component of soil silo pressure between the walls, kPa.

7.44 Intensity of the horizontal component of passive soil pressure p_p at a flat soil surface is determined in accordance to the formula

$$p_p = p_{\text{p,гр}} + p_{\text{рн}}, \tag{7.28}$$

where $p_{p,\text{гр}}$ is intensity of the horizontal component of passive pressure from the weight of the soil, kPa, determined by the paragraph 7.45;

$p_{p\text{н}}$ is is the intensity of the horizontal component of the passive soil pressure from the load on the outlift triangle, kPa, determined by the paragraph 7.47.

7.45 Intensity of the horizontal component of passive pressure from the weight of the soil, $p_{p.\text{гр}}$,, determined according to the formula

$$p_{p,\text{гр}} = q_z\lambda_p + c\lambda_{pc}, \tag{7.29}$$

where q_z is intensity of vertical soil pressure, kPa, (paragraph 7.35);

λ_p is coefficient of the horizontal component of passive soil pressure, which is determined according to the paragraph 7.46;

c is specific soil cohesion, kPa;

λ_{pc} is coefficient of the horizontal component of passive soil pressure from the cohesion forces, determined by the paragraph 7.46.

For the surface layer, where soil structure may be disturbed, the specific soil cohesion is c=0, and the full value of cohesion is taken at a depth of 1.0 m. Change in the specific cohesion to its full value is assumed to be linear.

7.46 Coefficient of the horizontal component of passive soil pressure λ_p is determined in accordance with the requirements of СНиП 2.06.07-87 according to the following formulas:

if $\rho = 0$,

$$\lambda_p = \frac{\cos\delta + \sqrt{\sin^2\varphi + \sin^2\delta}}{\cos^2\alpha\,(1-\sin\varphi)} \times exp\left[\left(\delta + \arcsin\frac{\sin\delta}{\sin\varphi} + 2\alpha\right)\tan\varphi\right], \tag{7.30}$$

where ρ is angle of inclination of the soil surface to the horizontal, degrees, which is taken with a plus sign if raising the territory level mark;

δ is angle of soil friction over the design plane, degrees, which is taken from 0 to φ, but not more than 30°;

α is angle of inclination of the design plane to the vertical, degrees, taken with a minus sign when inclined from the ground кут нахилу розрахункової площини до вертикалі, град, що приймається зі знаком мінус при нахилі від ґрунту;

при $\rho \leq \varphi$ i ((7

$$\lambda_p = \left[\frac{\cos(\varphi-\alpha)}{\cos\left(1-\sqrt{k_4}\right)}\right]^2, \tag{7.31}$$

де

$$k_4 = \frac{\sin(\varphi + \beta)\sin(\varphi + \rho)}{\cos(\alpha + \beta)\cos(\alpha - \rho)}, \quad (7.32)$$

where β is an angle, degrees, taken equal to δ in case $\delta \leq 0{,}33\varphi$, and equal to $0{,}677\varphi$ in case $\delta > 0{,}33\varphi$.

Coefficient of the horizontal component of passive soil pressure from the cohesion forces λ_{pc} is determined according to the formula

$$\lambda_{pc} = \frac{0.9\lambda_p - 1 + \tan\alpha \tan\delta}{\tan\varphi}, \quad (7.33)$$

7.47 Intensity of the horizontal component of passive soil pressure $p_{p,qn}$ from the load on the outlift triangle.

$$p_{p,q\text{п}} = 0.9 q_{\text{п}} \lambda_p, \quad (7.34)$$

where $q_{\text{п}}$ is load intensity on the outlift triangle, kPa, assumed to be infinite along the structure width.

7.48 If soil surface has a slope in front of the structure (Fig. 7.3 a, b), the epure of intensity of the horizontal component of passive soil pressure will be determined by two epures:

a) epure 1, constructed from the point of intersection of the line that continues a slope with the design plane, as for an unlimited slope;

b) epure 2, constructed from the point of intersection of the line that continues a horizontal surface of a half-slope or berm, taking a design plane as for a horizontal soil surface; in this case, for the scheme in Fig. 7.3a, epure 2 is constructed from point 0, where the intensity of passive soil pressure will be determined as for an infinite slope.

Epure 3 is taken depending on the ground surface contour in front of the structure:

– for contour given in the Fig. 7.3a, from the top of the design plane to point 0 located at the depth of Δd according to the epure 1, if deeper - according to the epure 2;

– for contour given in the Fig. 7.3b, from the top of the design plane to point 0 (the point of intersection of epures 1 and 2) - according to the epure 2; if deeper - according to the epure 1.

7.49 Intensity of the vertical component of passive soil pressure $p_{p,v}$ is determined according to the formula

$$p_{p,v} = p_p \tan(\alpha + \beta), \quad (7.35)$$

where p_p is intensity of horizontal component of passive soil pressure, kPa.

7.50 The horizontal E_p and vertical $E_{p,v}$ components of resultant passive soil pressure are determined by the area of the soil pressure intensity epures.

a) b)

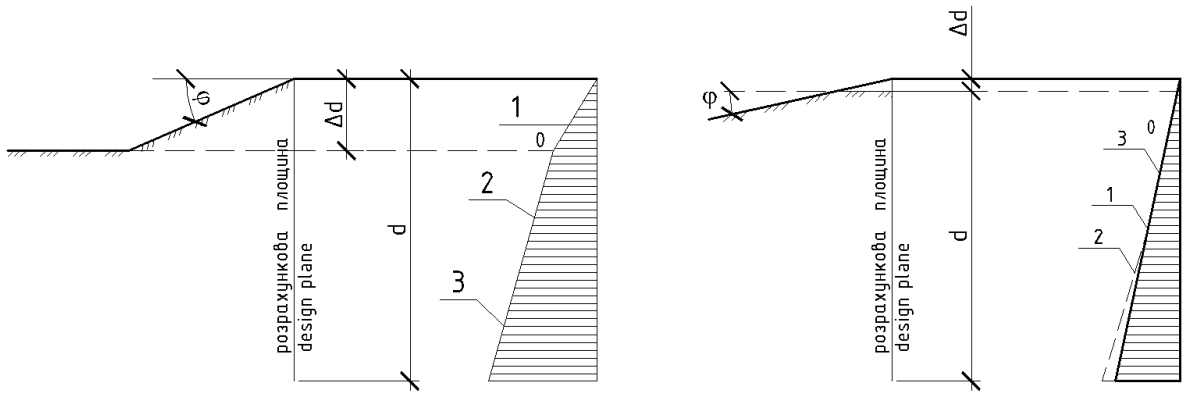


Fig.7.3

7.51 The intensity of soil pressure at rest on the vertical design plane in case of horizontal soil surface is determined as active pressure in accordance with the instructions of the paraagraphs 7.33 and 7.39, considering coefficient of the horizontal component of active soil pressure should be equal to the coefficient λ_0.

7.52 Coefficient of lateral soil pressure at rest λ_0 is determined according to the formula

$$\lambda_0 = \frac{\upsilon}{1-\upsilon}, \tag{7.36}$$

where ν is a coefficient of lateral soil deformation, which is taken for lack of empirical data, in accordance with the Standard СНиП 2.02.02-85.

7.53 When determining the reactive soil pressure caused by the displacement of a structure, the soil will be considered as a linearly deformed base characterized by the deformation modulus $E_{\text{п}}$ and the coefficient of lateral soil deformation ν, or the coefficient of subgrade resistance c_z.

7.54 The modulus of soil deformation $E_{\text{п}}$ should be taken on the basis of laboratory testing or field survey data in accordance with the requirements of the Standard СНиП 2.02.02-85.

The coefficient of subgrade resistance c_z is assumed to be linearly increasing as depth increases

$$c_z = kz, \tag{7.37}$$

where k is a coefficient of proportionality of soil elastic properties, kN/m4, taken according to the Table 7.1.

z is a current coordinate of the wall height, m.

Table 7.1 Coefficients of proportionality of soil elastic properties,

Description and characteristics of soils	**C , kN/m^4**
Clay and loam, liquid plastic (0,75< I_L ≤1,00)	500-2000
Clay and loam, soft plastic (0,50< I_L ≤0,75), sandy loam, soft (0< I_L ≤1,00), sandy silt (0,60<e<0,80)	2000-4000
Clay and loam, stiff plastic and half hard (0< I_L ≤0,50), sandy loam, hard (I_L < 0) and sand, fine- (0,60<e≤0,75) and medium-grained (0,55<e≤0,70)	4000-6000
Clay and loam, hard (I_L <0), sand, coarse (0,55<e ≤0,70)	6000-10000
Sand, gravelly (0,55<e ≤0,70), gravel and pebble, sand filled	10000-20000

Notes:

1. ***The lowest values of the coefficient C correspond to higher values of the liquidity index I_L of clayey soils and porosity coefficients of sandy soils given in brackets, and higher values of the coefficient C correspond to lower values of I_L and e, respectively. For soils with intermediate values of I_L and e, the values of the C coefficient are determined by interpolation.***
2. ***The coefficients C for dense sands (e ≤ 0.55) are taken 30% higher than the highest values specified for this type of soil.***
3. ***Coefficients k for bulk soils are taken 30% lower than the values indicated in the table for this type of soil.***

7.55 In calculations of strength, stability, and deformation the intensity of reactive soil pressure shall not exceed the intensity of passive soil pressure determined in accordance with paragraph 7.44.

Main constructional requirements for the design of structures applying sheet piles walls made of steel pipe piles (ШТЗ) and H-beam sheet piles (ШБЗ)

7.56 This guidance extends to design of the structures applying ШТЗ and ШБЗ, including unanchored and anchored walls with single level anchoring.

7.57 The design and arrangement of the elements of a structure should ensure that their load-bearing capacity is used at maximum possible extent, and the forces and strains between the elements are most favorably distributed.

7.58 ШТЗ and ШБЗ systems are used as the main elements of structures. It is allowed to use any steel profile matching the durability and safety requirements for structure operational conditions under consideration.

7.59 In the design of face walls, particular attention should be paid to ensuring that the full height of the wall is soil-proof, and 1.5 m below the design bottom elevation.

7.60 To release hydrostatic pressure behind the wall, drainage outlets should be provided below the design water level at the structure.

7.61 Where necessary, the elements of the face wall should be connected on top by a superstructure of precast or cast-in-place reinforced concrete. The dimensions of the header depend on a number of factors (corrosion protection, safety, for berthing and protecting structures, - installation of mooring units and fenders, etc.).

7.62 The bottom elevation of reinforced concrete superstructures should be determined based on the necessity to protect ШТЗ and ШБЗ from aggressive impacts in a variable water level zone.

For hydroengineering structures being constructed in the areas with high aggressive water or possible high ice loads, the bottom elevation of the superstructure should be at least 0.2 m below the design level.

When constructing structures in the area of low aggressive impacts, where long-term safety of ШТЗ and ШБЗ is ensured, the bottom elevation of the superstructure should be determined if a supporting area for fenders and dry erection of the superstructure are provided.

7.63 Expansion joints in reinforced concrete superstructure and face wall headers should be located at intervals not exceeding 50-55 m, as well as in places of abrupt changes in soil conditions that may cause differences in shear values of separate parts of the structure.

Expansion joints in the reinforced concrete superstructure should be made in the places of interlocking systems, where horizontal and vertical deformations can be realized.

7.64 Reinforced concrete slabs, piles, sheet piles, shell-type piles, steel pipes and other hot-rolled profiles, as well as welded and composite volumetric structures should be used for anchor support structures.

7.65 Structures with multi-row shielding (more than two rows of shield elements) should be used only when it is necessary to ensure the overall stability of the structure or when the shield elements are used as supports for process equipment, including crane tracks.

7.66 When making layout of structures, it should be taken into account that the shielding effect increases as share of the shielding walls stiffness increases in the system.

The greatest efficiency is realized when the front and shielding walls are restrained, which is ensured by the optimal ratio of immersion depth, distance between the walls and anchoring flexibility, which is achieved by considering and calculating several layout alternatives.

7.67 The distance between the front and shielding walls of the structure, as well as between the shielding walls, should be taken based on the bearing capacity of the wall elements and the

optimal stress state of the entire system, if possible, equal. It is recommended to install them in the range of 0.15-0.30 h (h is the wall height).

7.68 Shielding walls shall be constructed as a continuous row or of the space-immersed elements. The clearance between the wall elements should not exceed the distance to the wall in front.

7.69 The relieving platform should cover space between the front wall and the shielding walls and abut freely against the front wall of the structure.

The difference between the elevations of bottom of the relieving platform and the axis of the anchor rods should be minimal, not exceeding 0.5 m.

The reinforced concrete platform can be precast or cast-in-place and placed symmetrically with respect to the axes of the shielding walls of the structure.

In case of multi-row shielding, a cast-in-place platform is allowed along the entire cross-section, as well as with a movement joint in the middle of the span between the walls.

7.70 Anchoring should be carried out using the distribution waling of the front wall, and in the case of large-sized elements of high stiffness, it should be carried out for each element.

When designing the anchor rod attachment unit, it is recommended to ensure the possibility of free rotation of the anchor rod by 5 – 10 degrees from the normal to the anchored wall.

To reduce the irregular loading of the anchor rods and to bring their deformations to a value that ensures normal wall operation, it is recommended to include special clutches and devices in the rods.

7.71 Steel anchor rods should be protected against corrosion. Bituminous, epoxy and epoxy - coal-tar enamels, sealants and tape materials can be used as protection.

It is recommended to fill the fastening points and connections of the anchor rods with bitumen-rubber enamel.

7.72 For the installation of anchor rods, it is recommended that temporary support structures be provided during the works, and removed after the anchors are tightened.

7.73 Anchoring of structures with shielding walls can be performed according to two schemes:

– for the front wall with the shielding walls abutted to the front wall through the relieving platform;

– for the shielding wall with additional anchoring of the front wall for the shielding wall.

The second scheme is recommended for high-stiff shielding walls.

When anchoring according to the first scheme, special cross-bars should be installed between the walls to ensure joint operation of the walls during backfilling.

Basic schemes of rods anchorage are given in Appendix 9.9. Other schemes of anchor rods anchorage are also allowed.

The distribution waling should be cut in accordance with the cutting of the superstructures, but not more than 40 m away.

Within a section, the beams must be welded by equal-strength seams or by bridge welding.

It is permissible to install distribution waling beams with open butt welds, taking into account the design schemes of the beam in accordance with their specific cut type.

7.74 When designing the construction technology, the order of operations should be related to the possibility of gaining the most favorable stress state in the structural elements by artificially adjusted shear of anchorage assembly.

7.75 Other basic construction requirements for applying ШТЗ and ШБЗ in different fields of application are given in Article 8.

Basic principles of calculation in design of structures applying ШТЗ and ШБЗ

7.76 The calculation should be based on boundary states. Loads and their combinations should be taken in accordance with the requirements of the regulations, including for structures subject to additional requirements.

7.77 Loads and their combinations should be determined in accordance with the following provisions:

– loads from water filtration pressure (for all types of structures) and water wave pressure (for hydroengineering structures) are summed up with the loads and impacts on the face wall;

– vessels loads from the side of the port water area (for hydroengineering structures), as well as ice loads, are included in the strength calculation of the walls and superstructure, its connection with wall elements, fenders and their anchoring.

7.78 The calculation should take into account the displacements and deformations of the elements. The calculation includes pre-setting the initial geometric, stiffness and force parameters, determining the depth of driving the wall elements, static calculation of the front and shielding (if any) walls, anchoring units, and calculation of structural elements.

7.79 Front and anchor walls, and slabs should be calculated taking into account the soil friction .

The angle of friction of the backfill material and the subgrade soil along the design plane of the wall in the outward pressure triangle is assumed to be 0.667φ, but not more than 30°.

The angle of soil friction along the design plane in the outlift triangle is assumed to be equal to φ for the front and shielding walls, as well as for the anchor walls and slabs, but not more than 30°.

When replacing the soil at the base of the front wall, the friction angle of the backfill material along the design plane in the outlift triangle should be taken as 0.33 φ.

7.80 The design plane of the front wall should be accepted as follows:

– a plane passing along the back flange or surface - for walls made of ШБ3;

– a plane passing at a distance of 0.25 diameter from the wall axis towards the backfill - for walls made of ШТ3.

7.81 The design plane of a shielding wall of the spaced elements, if there is one shielding wall, should be accepted as a plane located at a distance of Δ from its front face.

For elements of circular cross-section, the value Δ is determined according to the formula

$$\Delta a = \frac{[a_э - d_э \tan(45 - 0{,}5\varphi_{red})]^2}{4a_э \tan \varphi_{red}}, \qquad (7.37)$$

where $a_э$ is a distance between the axes of the shielding wall elements, m;

$d_э$ is a diameter of the wall shielding element, m;

φ_{red} is a weighted average value of the internal friction angle within the height of the shielding wall, degrees.

For square and rectangular elements, the value of Δ_a is determined by the formula

$$\Delta a = \frac{(a_э - b_э)}{4a_э \tan \varphi_{red}}, \qquad (7.38)$$

where $b_э$ is width of the wall shielding element along the structure length, m.

In case of one shielding wall driven by a continuous row, the design plane is determined as for the front wall (paragraph 7.80), depending on the side against which the lateral ground pressure is considered.

In case of two or more shielding walls, their design planes are taken along the neutral axis of the elements cross-section.

7.82 In case there are weak clayey soils and silts in the subgrade, it should be necessary to consider their condition at the time of a structure loading (unstabilised, partially consolidated, stabilised).

With this the conditions of mentioned soils bedding, the methods of work execution and the speed of construction, the period of time from the cavities backfilling to the start of operation

and loading of a structure should be considered. It should be noted that accelerated rates of backfilling and loading may cause the full pore pressure in the considered soil.

Considering the design and construction experience, it is allowed to use the shear values φ and c from engineering and geological reports for unstabilised soil conditions when determining the lateral soil pressure on the walls.

In case of partial replacement of weak clayey and silt soils in the structure subgrade and placement of a filter soil layer on their surface, as well as in case of natural occurrence of weak clayey soil adjacent to the filter layer, it is necessary to make a through-time calculation under the load of partial soil consolidation before the operation starts.

7.83 The minimum permissible depth of the wall elements driving should be determined by calculation of depth shear stability assuming circular cylindrical or flat (broken) sliding surfaces. круглоциліндричних або плоских (ламаних) поверхонь ковзання.

7.84 The front unanchored wall should be calculated as a cantilever beam for active pressure from the weight of the soil and operational loads on the site.

The accepted design scheme is a 1 m wide beam of $B_{л}$ stiffness along the front of the structure, located below the bottom level in an elastic base, characterised by a coefficient of subgrade resistance that increases linearly with depth.

The coefficient of subgrade resistance is determined in accordance with the paragraph 7.54.

Note. In cases the upper layer below the bottom level contains weak silty soils with a thickness of more than 0.3 of the wall elements driving depth, the proportionality coefficient for determining the subgrade resistance coefficient should be taken as for the upper layer.

7.85 The design depth of the front unanchored wall driving should be accepted not less than the greater of forces obtained from the equation of equilibrium moments from the of active and passive soil pressure on the bottom of the wall and stability calculation (paragraph 7.83).

7.86 The front wall of an anchored structure should be designed as a statically indeterminate beam for active pressure from the soil weight and the site operational loads.

The accepted design scheme is a 1 m wide beam with stiffness $B_{л}$ along the front of the structure, resting on an elastic foil bearing at the anchor point and placed below the bottom level in an elastic base characterised by a subgrade resistance coefficient (paragraph 7.84).

7.87 Active ground pressure on the front wall of a shielded structure should be determined separately for the over-anchor and span sections.

The over-anchor section is subject to pressure from the backfill soil weight above the relieving platform and the site operational loads.

The span section is subject to silo soil pressure between the walls and the additional pressure, which is determined by the soil pressure distribution factor in the system that considers the stiffness characteristics of the structure walls.

The additional soil pressure is determined by summing up the pressure from the weight of soil behind the shielding walls, which is transferred to the front wall according to stress distribution laws in a linearly deformed medium, and the site operational loads behind the relieving platform (including the soil weight of the over-anchor section).

7.88 The front wall of a shielded structure shall be calculated in the same way as a front wall of an anchored structure (paragraph 7.86).

7.89 The depth of the front wall elements driving obtained from the stability calculation (paragraph 7.83) should be verified from the stability condition of rotation around the anchorage point under active and passive soil pressure.

The design depth of the structure front wall elements driving is accepted to be not less than the greatest of the calculated depths.

7.90 The shielding walls of the structure should be designed to withstand active pressure from the soil weight (paragraphs 7.91, 7.92) and operational loads in the area behind the relieving platform (including the soil weight of the over-anchor section), considering the soil pressure distribution factors in the system.

7.91 Active soil-weight pressure for a single shielding wall structure is the difference between the soil-weight pressure of the soil below the anchor elevation and the silo soil pressure between the walls.

7.92 Active pressure from the soil weight for a structure with two shielding walls should be determined as follows:

– for the first shielding wall it should be the difference of pressure between the walls, taking into account the additional pressure from the soil weight behind the second wall, which is transferred to the shielding wall according to the laws of stress distribution in a linearly deformable medium;

– for the second shielding wall it should be similar to active pressure determined in accordance with the paragraph 7.91.

7.93 The shielding wall of a structure should be calculated as a statically indeterminate beam. The design scheme of the shielding wall is assumed to be a 1 m wide beam with stiffness $B_{e,i}$ along the front of the structure resting at the anchor point on an elastic foil support and located below the level of the conventional free surface (CFS level) in elastic base characterised by a subgrade resistance coefficient.

Position of CFS level is determined from the anchoring point by $h_{e,i}$ value (Fig. 7.4), which is calculated according to the formula

$$h_{e,i} = 1.5(l_л - a_i \tan \varphi_i) - 0.5(h_л + d_{min}), \quad (7.39)$$

where $l_л$ is a conventional span of the structure front wall, m, that is determined according to the formula (7.40);

a_i is a distance between the design plane of the front wall and the design plane of the corresponding shielding wall, m;

φ_i is an angle of internal friction of soil in the layer located at a distance $l_л$ from the anchor attachment level, degrees;

h is height from the anchor attachment level to the bottom, m;

d_{min} is minimum permissible driving depth of the shielding wall elements, m. (see the paragraph 7.83).

Conventional span of the front wall of the structure is recommended to be determined according to the formula

$$l_л = h_л + 0.67d_л, \quad (7.40)$$

where $d_л$ is driving depth of the front wall, m.

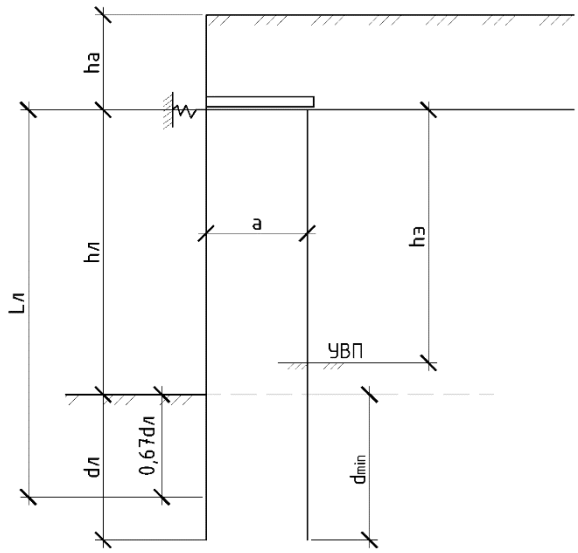


Fig. 7.4. Scheme for determination of CFS level position.

7.94 The displacement of the front wall at the level of anchor attachment should be determined according to the following formula

$$U_a = \frac{0.75 l_a R_y}{E_a} + U, \quad (7.41)$$

where l_a is an anchor length (distance between the design plane of a structure front wall and the anchor support), m, determined according to the paragraph 7.106;

R_y is design resistance of the anchor material, kPa, accepted in accordance with the Standard ДБН В.2.6-198:2014 ;

E_a is a modulus of elasticity of the anchor material, kPa;

U is a displacement of the anchor support, m, determined by the calculation.

In cases the front wall is anchored by the shielding wall and the shielding wall - by the anchor support, when determining the displacement of the screening wall, the length of the anchor l_a is accepted equal to the distance between the design plane of the shielding wall to the anchor support.

Notes:

For optimal forces distribution in the structure elements, it is recommended to vary the value of wall displacement at the level of anchor attachment, which can be provided either by the construction technology or by structural devices.

The horizontal movement of a gantry support only at the level of anchor attachment is assumed to be zero

7.95 Static calculation of the front and shielding walls of the structure is recommended to be done using PLAXIS, MIDAS GTS NX or similar software that allows performing linear and nonlinear static calculations of structures based on the elasticity and plasticity theories; calculations of foundation soils consolidation; calculations of stresses and displacements in soils with regard to their filtration (for the foundations of buildings and structures); dynamic calculations of foundations and structures using the relations from the theory of linearly deformed and nonlinearly deformed media, etc.

Note. It is allowed to use the Blum-Lomeier or Jacobi method for approximate wall calculations.

7.96 Static calculation of an anchored structure front wall of (including shielded structures), considering the loads from filtration pressure (for all types of structures) and wave pressure of water (for hydroengineering structures), should be carried out in two stages:

– at the first stage, the calculation is made for active pressure from the soil weight and operational loads on the site;

– at the second stage,- including additional loads from filtration and wave water pressure.

The calculated maximum bending moment $M_л$ in the front wall element is determined according to the formula

$$M_л = M_{max} + (M_2 - M_1)(b_л + a_л), \qquad (7.42)$$

where M_{max} is maximum bending moment in the front wall element, kNm, obtained at the first stage of the calculation;

M_2, M_1 is maximum bending moment (per 1 m of the wall along the structure length), kN ·m/m, obtained from filtration and wave pressure correspondingly;

$b_л$ is width of the element along the structure length, m;

$a_л$ is distance (design spacing) between the elements, m.

Design anchor reaction per 1 m of the wall along the structure length should be determined by static calculation at the second stage.

Note. In case of steel sheet pile, calculation of maximum bending moment should be made per 1 m along the wall length.

7.97 The forces (bending moments) in the wall elements from berthing impact and ice loads should be summed up with the forces obtained by static calculation in accordance with the paragraph 7.95.

7.98 Anchor walls and slabs should be calculated in the following cases:

– when determining total load stability (height) from active and passive soil pressure, including the operational loads in the site behind the anchor support, and the anchor force R_a;

– when determining reactive soil pressure strength in front of the support caused by the anchoring force R_g;

– when determining forces from mooring impact determined in accordance with the paragraph 7.99 (only for hydrotechnical structures).

The value of the anchoring force R_g per 1 m of wall along the structure length is equal to the design anchoring reaction obtained by static calculation according to the paragraph 7.95 with the coefficient K_a that considers the redistribution of the active soil pressure epure, irregular tension of anchors, and soil hang-up upon the anchors.

The coefficient K_a is assumed to be 1.5.

Notes:

1. ***In the first approximation, the value of anchoring force R_a is taken by analogs ***
2. ***Forces from mooring effects for hydroengineering structures are taken into account only in case of bollard blocks calculation***

7.99 The force from the design berthing load for hydrjengineering structures, taking into account the height of its application in relation to the anchor attachment level, is determined according to the formula

$$S_{ш} = \frac{S_g}{l_T}\left(1 + \frac{h_з}{l_л}\right), \qquad (7.43)$$

where S_g is a transverse projection of the design berthing load, kN, determined in accordance with the requirements of the Standard 2.06.04-82*;

l_T is length of a bollard block, m;

h_s is height from the level of anchor attachment level along the line of load action S_g , m;

$l_л$ is conventional span of the front wall determined by its static calculation.

The force from the berthing load is summed up with the anchoring force R_a.

7.100 The anchor wall shall be calculated by conventional methods of structural mechanics in accordance with the programs required in the paragraph 7.95.

7.101 The anchor plate should be calculated as a double cantilever beam with support at the anchor point.

Forces acting in the transverse direction in the elements of reinforced concrete anchor plates that have T-shaped or ribbed sections are determined as follows:

– in a slab between the ribs - as in a beam upon two supports with cantilevers;

– in a flange as in a cantilevered beam, restrained at the point of the flange abutting the rib.

The anchor plate should be calculated in accordance with the programs specified in the paragraph 7.95.

7.102 Anchored gantry supports should be calculated for: the vertical load from the weight of the cap beam and the weight of the soil above it, and for the compressed piles, - from the additional operational loads in the site; and the horizontal loads equal to the anchoring force (paragraph 7.98).

Vertical loads are taken along a structure length equal to the spacing of the pile gantry supports.

7.103 The longitudinal compressive forces N_c and tensile forces N_p in gantry piles are determined graphically (Fig. 7.5) or according to the following formulas:

$$N_c = F\frac{\sin\alpha_p}{\sin(\alpha_c+\alpha_p)} + R_a S_k \frac{\cos\alpha_p}{\cos(\alpha_c+\alpha_p)} + G_c, \quad (7.44)$$

$$N_p = F\frac{\sin\alpha_c}{\sin(\alpha_c+\alpha_p)} + R_a S_k \frac{\cos\alpha_c}{\cos(\alpha_c+\alpha_p)} + G_c, \quad (7.45)$$

where F is design vertical load, kN;

α_p , α_c are angles of inclination to the vertical of the tensile and compressed gantry piles, respectively, degrees;

R_a is anchoring force, kN/m (see paragraph 7.98);

S_k is spacing of pile gantry supports, m;

G_c is weight of a pile in the structure, kN, determined with the load safety factor γ_f = 1,05 for a compressed gantry pile and γ_f = 0,95 for a tensile gantry pile.

7.104 Bearing capacity and depth of gantry piles driving should be calculated in accordance with the requirements of the Standards ДБН В.2.1-10:2009 and ДСТУ Б.В.2.1-27:2010.

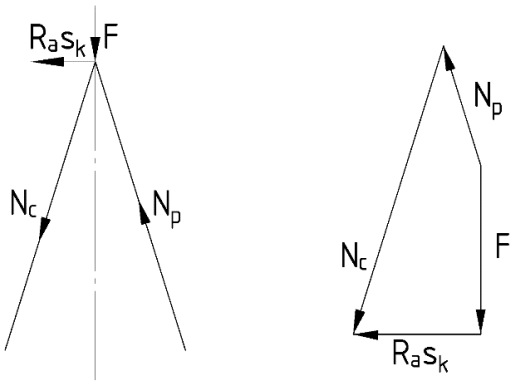


Fig. 7.5. Scheme for determining forces in gantry piles

7.105 The distance between the design plane of the front (shielding) wall of the structure and the anchor support (anchor length l_a) should be taken in case of intersection of the fall plane, drawn from the design plane from a point at the level of the conventional span of the wall, with the outlift plane, drawn from the anchor plate foot, and for the anchor wall – drawn from a point extending upward from the foot at $2\Delta d$ distance (Δd is the additional restraint depth) on the surface of the site.

7.106 If it is possible or advisable to bring the anchor wall or slab closer to the front (shielding) wall due to layout requirements (because of the site constraints, etc.) or feasibility studies, or if there are much stronger soils between the face (shielding) wall and the anchorage devices than the backfill soils at the surface soils layers of the foundation, the stability of the soil mass supporting the anchorage of the structure should be checked.

7.107 It is recommended to place gantry anchorage supports directly behind the natural slope line.

In cases the supports are close to the front (shielding) wall, the bearing capacity of the pile sections located above the natural slope should be accepted to be not more than 50% of bearing capacity determined for the same soil in natural conditions.

7.108 Tension calculation of the anchor rods should be made considering the strength conditions.

$$\gamma_{1c} \frac{R_{\text{ат}}}{A_n} \leq \frac{\gamma_c}{\gamma_{\text{п}}} R_y, \tag{7.46}$$

where γ_{lc} is a load combination coefficient;

$\gamma_{\text{п}}$ is a safety coefficient of the structure;

$R_{\text{ат}}$ is tensile force in the anchor rod, kN, determined according to the paragraph 7.109;

A_n is net cross-section area of the rod, m^2;

γ_c – the coefficient of working conditions accepted equal to 1;

R_y – designed tensile resistance of anchor rod material,kPa;

In threaded connections, the design cross-section of the rod should be accepted according to the internal diameter of the thread.

7.109 Tensile force in the anchor rod should be determined according to the formula

$$R_{\text{ат}} = \frac{R_a S_a}{\cos \alpha}, \tag{7.47}$$

where R_a is anchor force, kN/m (see.paragraph 7.98);

S_a is anchor spacing, m;

α is an angle of the anchor rod inclination to the hroizontal, degrees.

In case the front wall is anchored to the shielding wall, and the shielding wall is anchored to the anchor support in a shielded structure, the force in the front anchor is determined according to the formula

$$R_{\text{ат}} = \frac{K_a R_{\text{л}} S_{\text{п}}}{\cos \alpha_{\text{п}}}, \tag{7.48}$$

where K_a is a coefficient accepted according to the paragraph 7.98;

$R_{\text{л}}$ is force in a front anchor at 1 m of the wall along the structure length, kN/m, equal to design anchor reaction of the front wall obtained by a static calculation according to the paragraph 7.95;

$S_{\text{п}}$ is front anchors spacing, m;

$\alpha_{\text{п}}$ is an angle of the front anchor rod inclination to the hroizontal, degrees.

When calculating the anchor rods of bollard units of hydoengineering structures, it is necessary to consider the forces from mooring impacts according to the paragraph 7.99.

7.110 Distribution waling should be calculated according to the schemes of multi-span continuous beams, taking into account the material plastic deformation.

The force for selecting the cross-section of distribution waling is recommended to be determined according to the following formulas:

$$M = \pm 0.085 R_a l^2, \tag{7.49}$$

$$Q = 0.5 R_a l, \tag{7.50}$$

where R_a is anchor force, kN/m (see paragraph.7.98);

l is design spacing of a multi-span beam, m, equal to the anchor spacing.

Cross-section of distribution waling should be determined by calculation of the bending strength in accordance with the requirements of the Standard ДБН В.2.6-198:2014.

7.111 The bolts for fixing the distribution waling and the nut pads are calculated for the forces assumed to be caused by uniform load distribution equal to R_{al} between the bolts.

The strength calculation of structural elements of the structure should be made according to the formula (7.1) with the coefficient of working conditions γ_c = 1.15, excluding strength calculation of the of anchor rods.

7.112 Strength calculation of the of anchor rods should be performed in accordance with the paragraph 7.108.

7.113 The deformation calculation of the face unanchored wall shall be carried out in accordance with the programs and their requirements specified in the paragraph 7.95.

Displacements of the wall should be determined for the design soils characteristics and loads used in the calculations for the second group of boundary states.

Displacement caused by operational loads cannot exceed the permissible displacements regulated by sectoral standards, unless there are special design requirements, For port facilities, the "Rules and Regulations for the Technical Operation of Port Facilities and Water Areas" should be used.

7.114 The calculation of the deformations of the anchor supports should be made for the design soils characteristics and loads used in the calculations for the first group of boundary states.

7.115 It is allowed not to carry out the deformation calculations for the anchor rods and distribution waling.

7.116 In the calculations of the face wall of an anchored structure and the shielding walls of a shielded structure, it is recommended to increase the depth of their driving in comparison with the minimum permissible stability condition (paragraph 7.83) in cases it is appropriate to equalize the bending moments in span and restraint point, or when it is necessary to increase carrying capacity of the shielding wall for vertical loads.

7.117 In the calculation the face wall of a shielded structure, it is recommended to reduce the depth of its driving in comparison with the minimum permissible stability condition in cases when the drawn bending moment epure calculated in accordance with the paragraph 7.95, changes sign two or more times below the top level of the passive pressure epure, to a value determined by the level of the second intersection of the bending moment epure of the ordinate axis.

In this case, the driving depth of the front wall elements should not be less than that obtained from the condition of rotational stability around the anchor attachment point (paragraph 7.89).

7.118 In the calculation of a structure with two shielding walls, it is recommended to reduce the driving depth of the second shielding wall elements in comparison with the minimum permissible stability condition in cases the drawn bending moment epure calculated in accordance with the paragraph 7.95, changes sign two or more times below the level of the CFP, to a value

determined by the level of the second intersection of the bending moment epure of the ordinate axis.

At the same time, the stability and strength of the first shielding wall must be ensured.

Specific features of calculation of structures on weak soils

7.119 According to the Standard ДБН А.2.1-1:2008, weak soils include water-saturated clayey and silty soils characterized by at least one of the following features:

moisture level $S_r \geq 0.8$ and modulus of total deformation E ≤ 5000 kPa;

liquidity index $I_L \geq 0.75$; dynamic viscosity coefficient η less than 10^5 kPa per day, at normal stress $\sigma \geq 100$ kPa.

7.120 The design of structures on weak soils requires an assessment of the allowable deformations caused by viscous creep of weak soils.

7.121 The value of total long term deformations should be determined only in cases when matching the requirements of the structure overall stability results in the significant changes in the design of the structure that are not acceptable for technical or economic reasons.

7.122 It is recommended to determine the value of total long-term deformations of a structure in accordance with the procedure for their calculating by the programs and requirements to them as specified in the paragraph 7.95.

7.123 The design value of total long-term deformations is defined as the deep displacement of a soil mass over the design life of a structure according to the formula

$$u_j = u\frac{utr_j}{r}, \tag{7.51}$$

where j is an index of a point on the front wall where deformation is determined;

v is a linear deformation rate, m/day, along the tangent to the arc of the sliding surface of the sheared mass;

t is a the period of time per day corresponding to the design service life of the structure;

r_j is a radius, m, to the j-th point at which the deformation is determined;

r is a radius of a sheared mass, m.

7.124 The viscosity coefficients of the weak soil layers η, kPa×day and coefficients characterizing the change in viscosity with depth ζ, kPa×day/m, are necessary to determine the linear rate of deformation, may be determined as follows:

– viscosity coefficient η- according to the graphs at Fig. 7.6;

– coefficients characterizing the change in viscosity with depth, - according to the formula

$$\zeta = \gamma_{fred} \tan \psi, \qquad (7.52)$$

where γ_{fred} is a weighted average value of the specific gravity of overlying soil layers, kN/m^3;

ψ – tangent angles at the points of the graphs (see Fig. 7.6) corresponding to soil viscosity values along the line of the surface of deep shear, taking into account pore pressure and load.

In particularly critical cases, it is recommended to determine the coefficients η and ζ empirically based on the results of consolidated-drained tests of undisturbed soil samples at normal stresses corresponding to the weight of overlying soil layers, taking into account the operational load.

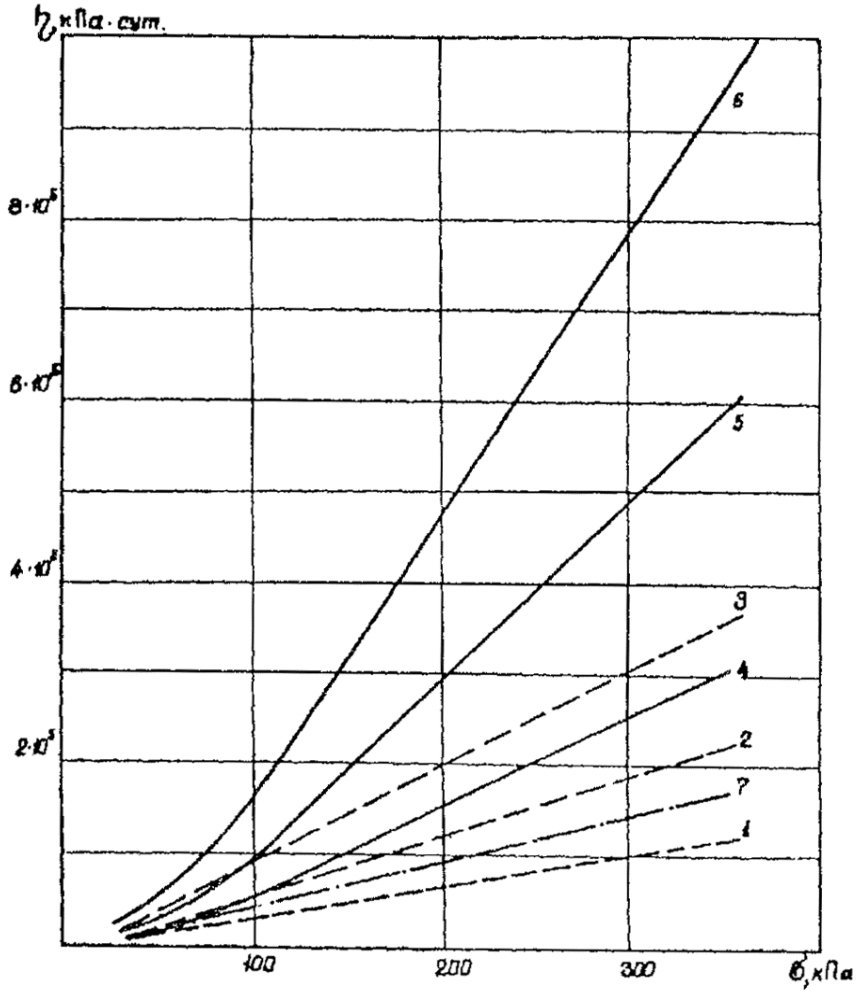


Fig. 7.6

7.125 In case of structures design on weak soils, it is generally recommended to provide pre-construction technical reclamation of weak subgrade soils (static or dynamic compaction, drainage, consolidation, etc.).

7.126 In cases the top of weak soil is located above the elevation of frost penetration depth and soil heaving may cause damage or significant deformation of a structure, the weak soils in the stated area should be removed and, if necessary, replaced with nonfrost-susceptible soils.

In all other cases, the replacement of weak soils should be justified by feasibility calculations.

Specific features of calculating service life of structures

7.127 The service life of a structure is assigned in the design statement.

7.128 In case the design sattement does not contain the instructions on the required service life of the structure, it is determined taking into account the requirements of the Standards ДСТУ 8855:2019 and ДБН В.1.2 14:2018.

7.129 For structures applying of ШТЗ and ШБЗ, it is necessary to provide in the design certain measures ensuring the assigned service life of the structure.

7.130 The measures shall be differentiated depending on the assigned service life of the structure.

7.131 The measures ensuring the service life of a structure are divided into organizational and technical measures.

7.132 Organizational measures at the design stage include: application of design schemes that exclude appearance of stress raisers in separate elements, calculations for steel fatigue, etc.

7.133 Organizational measures at the operation stage include: organization of regular technical supervision of the structures operation, compliance with the terms of inspection survey, timely execution of current and overhaul repairs.

7.134 Frequency of the activities specified in the paragraph 7.133 is governed by sectoral standards.

7.135 Technical measures include: protective painting, electrochemical corrosion protection of metal elements, making protective concrete (reinforced concrete) casings, caps in places of maximum corrosion hazard, etc.

7.136 The type of coating with protective paints and varnish and the area of their application depend on the area of structures location. It is recommended to use coatings with the maximum service life.

7.137 For temporary structures, it is permissible to minimize or renounce the protective measures. This shall be recorded in the design statement.

7.138 Applying ШТЗ and ШБЗ for structures with a service life from 50 to 100 years should be additionally justified by calculations, including fatigue and alternating loads. The thickness of the elements used should ensure corrosion resistance for the entire service life.

8 RECOMMENDATIONS FOR MANUFACTURE AND APPLICATION OF SHEET PILES WALLS MADE OF STEEL PIPE PILES (ШТЗ) AND H-BEAM SHEET PILES (ШБЗ).

General recommendations for manufacture of ШТЗ and ШБЗ sheet piles.

8.1 Manufacturing of ШТЗ and ШБЗ is carried out according to Technical specifications.

8.2 In technical terms, in addition to other indicators affecting the process of manufacturing, transportation and storage of products, the following should be included:

– maximum and minimum elements length;

– physical and chemical steels characteristics;

– permissible deviations from geometric dimensions;

– storage standards by height;

– admission conditions;

– transportation and storage rules;

– impacts on the environment.

General recommendations for application of ШТЗ and ШБЗ sheet piles.

8.3 Application field of ШТЗ and ШБЗ is given in the paragraph 4.4 of Methodical Guidelines. Typical examples of ШТЗ and ШБЗ application are given in Figs.4.1…4.12.

8.4 Choice of ШТЗ or ШБЗ application is carried out on comparing results of different factors: economical, technical, technological, ergonomical, architectural, etc.

8.5 In case the ergonomical, architectural or other special requirements are absent, the economic factors should be preferred.

8.6 Technical and technological factors can be considered in some cases upon pre-selection of contracting organization.

8.7 Effective combined sheet pile walls with «STEELWALL» interlocking systems can be used if the nomenclature of produced sheet pile locks is expanding. Design requirements for combined sheet pile walls are the same as to the sheet pile walls applying ШТЗ and ШБЗ, and are given in the Article 7.

8.8 Application of ШТЗ and ШБЗ requires to determine the grade of cross section.

8.9 Depending on the cross-section grade the permissible load on ШТЗ and ШБЗ is defined.

8.10 In design of ШТЗ and ШБЗ it is necessary to reach minimum the second cross-section grade according to the Eurocodes ДСТУ-Н Б EN 1993-1-1.

8.11 Required section grade is achieved through optimization of element thicknesses and overall dimensions of the beams.

8.12 It is appropriate to accept as limitation of beams degrees of freedom – using beams with interlocking systems in two beams chords– upper and lower.

8.13 The example of section grade determination is given in the Attachment 9.7.

8.14 After ШТЗ and ШБЗ section grade determination it is necessary to make calculations according to forces that are determined in compliance with the recommendations of the Article 7.

8.15 Algorithm of basic design cases calculation according to the Eurocodes is given in the Attachment 9.8.

8.16 In ШТЗ design, connecting interlocks should be placed in the neutral zone along the pipe axis. In places where the direction of the wall changes iterlocks should be placed at the angle of changing the direction of the wall according to axes of designed structure.

8.17 Limitation of the interlocks length within the soil is allowed if possible according to the results of the structure static calculation.

8.18 When ШБЗ designing it is advisable to use beams with interlocking systems in two beams chords. Meanwhile the design of auxiliary devises for piles driving is significantly simplified.

8.19 When ШБЗ designing it is necessary to strive for increase in storage tiers and decrease in the area of storage areas.

8.20 After transportation, the condition and quality of the locks should be carefully checked. It is necessary to carry out control pulling of the locking element with a length of at least 2 m everywhere in the pile lock.

8.21 When obstacles or deformed areas are detected, the piles are rejected with subsequent elimination of deficiencies and repeated control inspection.

8.22 The need for corrosion protection of piles is noted in the design. Corrosion protection of piles is done, as a rule, in factory conditions.

8.23 It is allowed to carry out corrosion protection of piles directly on the construction site, if there are appropriate equipment and a special room, temperature and humidity control in the room and other factors affecting the quality of the job.

8.24 Pile surface preparation for corrosion protection is carried out in accordance with the relevant regulations with either mechanized or manual tools.

8.25 Mechanized tools should be preferred.

8.26 The type of surface preparation is accepted depending on the type of paint coating provided by the design.

8.27 Special attention should be paid to the welds coating, where it is advisable to apply additional strip layers, and re-coating intervals in case of multi-layer coating.

8.28 Installation of piles in the design position should be carried out including the mandatory protection of those ШТЗ and ШБЗ sections where the slings are located.

8.29 The type of protection (a set of wooden rails, rubber sheets, etc.) is applied locally.

8.30 When choosing mechanisms for piles driving, in addition to the direct parameters affecting the driving, it is necessary to take into account the impact on nearby structures and minimize it.

8.31 It is recommended to drive the piles using inventory devices (conductors). Piles should be driven in one or more height levels.

8.32 The design of the inventory device for piles driving is developed as a part of design and survey work, taking into account the permissible deviations.

8.33 The permissible deviations are specified in the design. If there are no requirements for permissible deviations in the design, they are accepted according to standard documentation.

8.34 During the construction process, the separation of piles of ШТЗ and ШБЗ should be carried out in places of influence (for example, ice, wave, possible landslides, etc.), which can lead to loss of shape or destruction of the wall during the construction period.

8.35 It is advisable to mark each individual sheet pile.

8.36 Transportation and storage of sheet piles on the construction site must be carried out by a means that excludes significant violations of straightness, as well as damage to locks and protective surface coating.

8.37 Piles should be stored in such a way that they can be used in the order in which they are intended to be used.

8.38 Piles of various steel profiles and grades should be stored separately and marked accordingly.

8.39 In case piles are stored with protective coating, pads made of wooden beams or similar soft materials should be provided between separate piles in the stack to avoid deformation of the profiles.

8.40 Non-metallic belts and loops should be used to avoid damage to piles.

8.41 When lifting and positioning piles, special devices should be used, such as loading clamps, hook stops, etc.

8.42 In case remote-controlled cargo clamps used for piles lifting, their serviceability must be checked before use.

8.43 Edges processing and steel elements cutting should be carried out in such a way that the increase in brittleness of steel caused by electric arc cutting should not significantly impact on the quality of connection.

8.44 To facilitate the piles driving, washing, installation of pilot holes, blasting, etc. can be used.

8.45 To install the piles, it is necessary to choose a method that meets the design requirements for the wall deviations after its installation.

8.46 In case of closed construction of sheet pile walls, their closure must be carried out very carefully in terms of vertical and planar alignment of sheet piles position.

8.47 To prevent misalignment, it is not recommended to bevel or partially cut the pile foot, as this causes a risk of breaking the locks.

8.48 In case the piles are laterally inclined or twisted during the driving, such pile should be pulled out, except when other measures may be sufficient.

8.49 If during installation the pile has a bevel tendency, it is necessary to take immediate measures to counteract this phenomenon.

8.50 In case of piles removal, it is necessary to pay attention to the following factors:

– vertical and horizontal deformations in the nearest soil mass;
– the possibility of joining different aquifers.

8.51 If the piles are located near building structures sensitive to uneven settlement, the chemical production facilities, pipelines, or railway tracks, etc., pile removal operations should be carried out with special care. Cohesive soils can stick to the pile surface and thus leave a cavity in the soil when the piles are removed. In loose layers of sand and dusty soil, oscillations and cavities can cause displacement of the soil, which, in turn, can lead to damage to the nearest structures and equipment. Such displacements of soil and possible joining of aquifers can be avoided by filling of the cavities, for example, with a cement suspension at the time of piles removing.

8.52 If sheet piles have to be under vertical loads according to the design, the data of the last 3 meters of the sheet pile fence driving should be recorded, and location of the piles in hard rock should be excluded.

8.53 If groundwater level has a critical parameters according to the design, it should be monitored at intervals sufficient to obtain reliable information about groundwater level change.

8.54 After the work completion, it is recommended to continue monitoring of the groundwater level or control the pore pressures in the soil until the absence of negative consequences is confirmed.

Additional recommendations for specific fields of application.

Residential and civil construction

8.55 In residential and civil construction, ШТЗ and ШБЗ are used, as a rule, in the following cases:

– for fencing foundation pits with subsequent removal;

– for underground parkings;

– as analogue of continuous foundations;

– to construct man-holes for engineering networks;

– other cases, considering a combination of the above factors.

8.56 When designing pit fences, the height of ШТЗ and ШБЗ should include the height of the underground part, availability of aquifers, the loading on the near-by territory and other factors.

8.57 The number underground parking levels should be as high as possible based on the soil conditions and ШТЗ and ШБЗ parameters.

8.58 In the underground parkings construction, special attention should be paid to ensuring soil-proofing of the walls and bottom of the structure, and corrosion protection of the elements.

8.59 To reduce ШТЗ and ШБЗ cross-sections it is possible to use wall anchoring. At the same time, preference should be given, especially for temporary structures (foundation pit fences, etc.), to soil anchors, which are used, if necessary, in several levels.

8.60 Application of ШТЗ and ШБЗ in residential and civil construction should be carried out in compliance with the requirements specified in the following standards:

– ДБН В.2.2-15:2019. Buildings and structures. Residential buildings. General provisions.

– ДБН В.2.1-10:2018. Bases and foundations of buildings and structures. General provisions

– ДБН В.2.2-41:2019. High-rise buildings. General provisions

– ДБН В.1.2-12-2008. Construction in compacted building conditions. Safety requirements

– ДБН В.2.6-98:2009. Concrete and reinforced concrete structures. General provisions

– ДБН В.2.6-160-2010. Steel-reinforced concrete structures. General provisions

– ДБН В.2.6-198:2014. Steel structures. Design standards

– ДБН В.2.6-220:2017. Covering of buildings and structures

– ДСТУ Б В.2.6-193:2013. Corrosion protection of metal structures from. Design requirements

– ДСТУ Б В.2.6-199:2014. Steel structures for construction. Manufacturing requirements

– ДСТУ Б В.2.6-200:2014. Steel structures for construction. Installation requirements

– ДБН В.2.3-15:2007. Transport facilities, parkings and garages for passenger cars

– ДБН В.2.2-13-2003. Sports and health facilities

– ДБН В.2.2-10-2001. Healthcare institutions

– ДБН В.2.2-16:2019. Cultural and entertainment facilities

– ДБН В.2.2-25:2009. Catering establishments (restaurant industry)

– ДБН В.2.2-28:2010. Administrative and household buildings

– ДБН В.2.2-40:2018. Inclusiveness of buildings and structures. General provisions

– ДБН В.2.3-5:2018. Streets and roads of inhabited localit**ies**

– ДБН В.2.5-74:2013. Water supply. External networks and structures. Basic provisions of design

– ДБН В.2.5-75:2013. Sewerage. External networks and structures. General design provisions

– ДБН В.2.5-77:2014. Boiler houses

– ДБН В.2.2-9:2018. Buildings and structures. Public buildings and structures

– ДБН А.3.1-9:2015. Protecting structures of civil defense and their maintenance.

– ДСТУ Б В.2.6-10-96. Designs of buildings and structures. Steel designs for construction.

Load test methods and other standards regulating the design and construction process in this field.

Industrial construction

8.61 In industrial construction, ШТЗ and ШБЗ are used, as a rule, in similar cases to those given in paragraph 8.55, as well as for creating combined structures of foundations and walls of warehouses or other structures.

8.62 When designing warehouses and other structures, which are subject to additional requirements regarding temperature and humidity in the premises, special attention should be paid to protecting the walls from adverse hydrometeorological factors.

8.63 When designing combined constructions of foundations and walls of buildings, the type of ШТЗ and ШБЗ that will be adopted must ensure the calculated oscillation of the top of the

element, taking into account the dynamic characteristics of the roof. Finally the type of ШТЗ and ШБЗ is accepted based on the sum of costs for enclosing structures and roof elements.

8.64 ШТЗ and ШБЗ in industrial construction should be applied considering the requirements of the Standard СНиП 2.09.03-85 Industrial structures and the standard documents, the list of which is given in the paragraph 8.60.

Hydrotechnical construction

8.65 In hydrotechnical construction, ШТЗ and ШБЗ are used, as a rule, in the following cases:

– for construction of protecting structures;

– for construction of mooring structures;

– for construction of coast protecting structures;

– for construction of protecting structures of lighthouses and other navigational marks;

– for construction of man-made islands;

– for construction of cofferdams;

– for construction of other hydroengineering structures.

8.66 ШТЗ and ШБЗ in hydrotechnical construction should be applied taking into account the requirements of the following standard documents:

– ДБН В.2.4-3-2010. Hydrotechnical structures. General provisions.

– СНиП 2.02.02-85. Foundations of hydrotechnical structures.

– СНиП 2.06.04-82* Loads and impact on hydrotechnical structures (from waves, ice and ships).

– СНиП 2.06.07-87. Retaining walls, navigation locks, fish ladders and fish protection structures

– СНиП 2.06.09-84. Hydrotechnical tunnels

– СНиП 3.07.01-85. River hydrotechnical structures

– СНиП 3.07.02-87. Sea and river hydrotechnical transport structures

– ВСН 3-80. Instructions for marine mooring structures design

– РД 31.31.37-78 Norms of seaports technological design

– other standard documents regulating design and construction of hydrotechnical structures and the requirements stated in the Article 7.

8.67 Shielding effect for berthing and other structures, if necessary, should be considered according to the recommendations given in section 7.

8.68 In case of ШТЗ and ШБЗ application in mooring structures, it is necessary to take into account possible roll of the design vessel towards the wall up to 3°. The minimum gap between the wall and the vessel side should also be assigned taking into account the effect of the design wave. The size of the minimum gap between the wall and the vessel side is specified in the design, but shouldn’t be less than 10 cm.

8.69 As regards the protecting structures, it is necessary to study the feasibility of their functions combination and the possibility of developing port territories from the inside of the protecting structure. At the same time, special attention should be paid to ensuring the design service life of the structure.

8.70 Coast protecting structures applying ШТЗ and ШБЗ are of semi-inclined and vertical types. The specific type of coast protecting structure is determined depending on the technological requirements, features of the vertical layout of the site and other factors affecting the choice of the construction type.

8.71 When choosing the type of a coast protecting structure, semi-inclined structures should be preferred the design of which is the least sensitive to hydrological influences.

8.72 If it is necessary to moor to a coast protecting structure, it should be specified in the design statement.

8.73 If it is necessary to moor to a coast protecting structure and install mooring and/or fender devices at different levels, taking into account the fluctuation of the actual water level, it is allowed to moor them directly to the ШТЗ and ШБЗ elements, avoiding welding in the area of locks.

Bridge construction

8.74 In bridge construction, ШТЗ and ШБЗ are used, as a rule, in the following cases:

– for construction of the bridge footing;

– for construction of protecting structures for the bridge footing;

– for construction of the bridge junctions and coast protecting structures;

– for construction of the bridge temporary auxiliary structures.

8.75 In bridges construction the ШТЗ and ШБЗ should be applied in compliance with the requirements of the following standards:

– ДБН В.2.3-22:2009. Bridges and pipes. General design requirements.

– ДБН В.2.3-14:2006. Bridges and pipes. Design rules.

– ДБН В.2.3-26:2010. Transport facilities. Bridges and pipes. Steel structures. Design rules.

– and other standards regulating the process of bridge design and construction.

8.76 When applying the ШТЗ and ШБЗ, pay special attention to the possibility to take forces and movements due to temperature changes.

8.77 When designing protecting structures of the bridge footing, it is necessary to take into account the dimensions of existing and perspective watercraft and vessels to pass through the navigable span of the bridge.

8.78 Position of protecting structures of the bridge footing on timber rafting rivers should minimize possible blockage when passing rafts in the area of the bridge.

8.79 Position of protecting structures of the bridge footing should exclude the concentration of ice impacts.

8.80 When designing bridge connecting structures, special attention should be paid to determining their types to minimize loads, preserve the hydrological regime in the area of the structure and other influencing factors.

8.81 In construction of the bridge temporary auxiliary structures, the use of ШТЗ and ШБЗ should necessarily include the further removal of these elements and restoration of the bottom profile to preserve the original hydrological conditions.

8.82 On inclined viaducts sections, the dimensions should be assigned according tot the length of the maximum design vehicle (road train).

Construction of roads, retaining walls, underground structures, including underground passages

8.83 During the construction of roads, retaining walls, underground structures, including of underground passages the ШТЗ and ШБЗ are used, as a rule, in the following cases:

– for construction of retaining or other walls that significantly reduce the earthworks volume;

– for construction of road junctions in two or more levels;

– for installation of the elements regulating hydrological and other conditions - watercourses, animals passages, etc.;

– for construction of the underground passages;

– for construction of other structures in this field.

8.84 In construction of roads, retaining walls, underground structures, including underground passages ШТЗ and ШБЗ should be applied taking into account the requirements of the following standards:

– ДБН В.2.3-4-2015 Highway transportation facilities. Part 1. Design. Part II. Construction.

– ВСН 167-70. Technical guidelines for design of retaining walls for transport construction.

– ВСН 51-88. Instructions for expansion of highway bridges and overpasses.

– ДБН В.2.3-218-548:2010. Transport facilities. Reinforced soil retaining walls for highways. Design and construction.

– СНиП II-44-78. Railway and road tunnels.

– ДБН А.3.1-9:2015. Protecting structures of civil defense.

– ДБН В.2.2-5:2023. Protecting structures of civil defense.

– ДБН В.2.2-5:2023. Amendment №1. Protective structures of civil defense.

– ДБН В.2.3-7:2018. Metropolitans.

– and other standard documents regulating the process of design and construction of roads, retaining walls, and underground structures, including underground passages.

8.85 A structure type is chosen taking into account the characteristics of the construction site. While traditional methods of vertical pile driving should be preferred for new construction, it is advisable to use DTH technology with a horizontal method of driving and constructing underground structures, including arch-type underground passages, when working on existing structures.

8.86 For underground structures, including the arch type underground passages it is necessary at first to make calculation of the arch system including determination of the future structure dimensions and then to make calculation of the system according to the classical methods.

8.87 In roads and retaining walls design and construction, special attention should be paid to preserving the hydrological conditions of the structures location area.

8.88 For roads and retaining walls, it is expedient to implement single or multi-tier wall drains. Drain outlets through the ШТЗ and ШБЗ elements should be carried out bypassing the lock elements.

9 ATTACHMENTS

9.1 Attachment 1. Characteristics of pipe sheet piles made of pipes in compliance with State Standard of Ukraine ДСТУ 8943:2019.

This Attachment includes Tables 9.1.1…9.1.7 containing the characteristics of the pipe sheet pile and data for application of the connectors MF63, MF75, MF100, MF130, MF180a, MF180 b and MF 230.

Table 9.1.1 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ 8943:2019 and MF63 connectors.

Pipe characteristics					**Combination with MF63 connector**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys}, m**	**G97%**	**I_{sys}, cm^4**	**W_{sys}, cm^3**
820x10	254,47	199,76	208728	5091	0,88	243,21	236385	5766
820x12	304,61	239,12	248640	6064	0,88	287,79	281586	6867
820x14	354,50	278,28	287955	7023	0,88	332,14	326110	7954
820x16	404,13	317,25	326678	7968	0,88	376,27	369964	9024
820x18	453,52	356,01	364816	8898	0,88	420,17	413155	10077
820x20	502,65	394,58	402375	9814	0,88	463,85	455691	11114
820x22	551,54	432,96	439361	10716	0,88	507,31	497578	12136
820x24	600,17	471,13	475779	11604	0,88	550,54	538821	13142
820x26	648,55	509,11	511635	12479	0,88	593,55	579428	14133
820x28	696,68	546,89	546935	13340	0,88	636,34	619405	15108
820x30	744,56	584,48	581686	14187	0,88	678,91	658761	16067
920x10	285,88	224,42	295962	6434	0,98	243,56	301080	6545
920x12	342,31	268,71	352837	7670	0,98	288,61	358939	7803
920x14	398,48	312,81	408956	8890	0,98	333,48	416028	9044
920x16	454,40	356,7	464324	10094	0,98	378,12	472354	10269
920x18	510,07	400,4	518949	11282	0,98	422,58	527924	11477
920x20	565,49	443,91	572838	12453	0,98	466,84	582745	12668
1020x10	317,30	249,08	404638	7934	1,08	243,84	373627	7326
1020x12	380,01	298,31	482708	9465	1,08	289,29	445714	8740
1020x14	442,46	347,33	559843	10977	1,08	334,56	516937	10136
1020x16	504,67	396,16	636050	12472	1,08	379,65	587304	11516
1020x18	566,62	444,79	711337	13948	1,08	424,55	656821	12879
1020x20	628,32	493,23	785712	15406	1,08	469,28	725496	14225
1020x22	689,77	541,47	859182	16847	1,08	513,82	793335	15556
1020x24	750,97	589,51	931754	18270	1,08	558,18	860345	16870
1020x26	811,91	637,35	1003435	19675	1,08	602,35	926533	18167
1020x28	872,61	685	1074234	21063	1,08	646,35	991906	19449
1020x30	933,05	732,45	1144156	22434	1,08	690,16	1056469	20715

Pipe characteristics					Combination with MF63 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys}, m**	**G97%**	**I_{sys}, cm^4**	**W_{sys}, cm^3**
1020x32	993,25	779,7	1213210	23788	1,08	733,79	1120231	21965
1120x12	417,71	327,9	641079	11448	1,18	289,85	541910	9677
1120x14	486,44	381,86	743914	13284	1,18	335,47	628837	11229
1120x16	554,93	435,62	845626	15100	1,18	380,91	714815	12764
1120x18	623,17	489,19	946222	16897	1,18	426,19	799850	14283
1120x20	691,15	542,55	1045711	18673	1,18	471,30	883948	15784
1220x12	455,41	357,49	830778	13619	1,28	290,32	647528	10615
1220x14	530,43	416,38	964469	15811	1,28	336,22	751730	12323
1220x16	605,20	475,08	1096822	17981	1,28	381,98	854889	14015
1220x18	679,71	533,58	1227844	20129	1,28	427,57	957010	15689
1220x20	753,98	591,88	1357545	22255	1,28	473,01	1058102	17346
1420x12	530,80	416,68	1315469	18528	1,48	291,08	887032	12494
1420x14	618,39	485,44	1528224	21524	1,48	337,45	1030495	14514
1420x16	705,73	554	1739152	24495	1,48	383,68	1172726	16517
1420x18	792,81	622,36	1948265	27440	1,48	429,77	1313732	18503
1420x20	879,65	690,52	2155572	30360	1,48	475,74	1453521	20472
1620x12	606,20	475,87	1959402	24190	1,68	291,66	1164232	14373
1620x14	706,36	554,49	2277496	28117	1,68	338,38	1353236	16706
1620x16	806,26	632,91	2593201	32015	1,68	384,97	1540821	19023
1620x18	905,91	711,14	2906530	35883	1,68	431,45	1726993	21321
1620x20	1005,31	789,17	3217494	39722	1,68	477,82	1911761	23602
1820x12	681,60	535,06	2785195	30607	1,88	292,12	1479126	16254
1820x14	794,32	623,54	3238674	35590	1,88	339,11	1719954	18901
1820x16	906,79	711,83	3689127	40540	1,88	385,99	1959175	21529
1820x18	1019,01	799,92	4136567	45457	1,88	432,78	2196796	24141
1820x20	1130,97	887,81	4581008	50341	1,88	479,45	2432824	26734
2020x12	757,00	594,24	3815468	37777	2,08	292,48	1831718	18136
2020x14	882,28	692,59	4438149	43942	2,08	339,70	2130652	21096
2020x16	1007,32	790,75	5057090	50070	2,08	386,82	2427792	24037
2020x18	1132,10	888,7	5672307	56161	2,08	433,84	2723143	26962
2020x20	1256,64	986,46	6283814	62216	2,08	480,78	3016713	29868

Table 9.1.2 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ 8943:2019 and MF75 connectors.

Pipe characteristics					Combination with MF75 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
820x10	254,47	199,76	208728	5091	0,90	243,83	233216	5688
820x12	304,61	239,12	248640	6064	0,90	287,81	277810	6775
820x14	354,50	278,28	287955	7023	0,90	331,56	321737	7847
820x16	404,13	317,25	326678	7968	0,90	375,10	365003	8903
820x18	453,52	356,01	364816	8898	0,90	418,41	407616	9942
820x20	502,65	394,58	402375	9814	0,90	461,51	449581	10965
820x22	551,54	432,96	439361	10716	0,90	504,39	490906	11973
820x24	600,17	471,13	475779	11604	0,90	547,04	531597	12965
820x26	648,55	509,11	511635	12479	0,90	589,47	571659	13943
820x28	696,68	546,89	546935	13340	0,90	631,69	611101	14905
820x30	744,56	584,48	581686	14187	0,90	673,69	649928	15851
920x10	285,88	224,42	295962	6434	1,00	244,11	297449	6466
920x12	342,31	268,71	352837	7670	1,00	288,62	354610	7709
920x14	398,48	312,81	408956	8890	1,00	332,94	411011	8935
920x16	454,40	356,7	464324	10094	1,00	377,05	466657	10145
920x18	510,07	400,4	518949	11282	1,00	420,97	521557	11339
920x20	565,49	443,91	572838	12453	1,00	464,70	575717	12516
1020x10	317,30	249,08	404638	7934	1,10	244,34	369532	7246
1020x12	380,01	298,31	482708	9465	1,10	289,30	440829	8644
1020x14	442,46	347,33	559843	10977	1,10	334,06	511272	10025
1020x16	504,67	396,16	636050	12472	1,10	378,66	580868	11390
1020x18	566,62	444,79	711337	13948	1,10	423,07	649623	12738
1020x20	628,32	493,23	785712	15406	1,10	467,30	717545	14069
1020x22	689,77	541,47	859182	16847	1,10	511,36	784641	15385
1020x24	750,97	589,51	931754	18270	1,10	555,23	850917	16685
1020x26	811,91	637,35	1003435	19675	1,10	598,92	916379	17968
1020x28	872,61	685	1074234	21063	1,10	642,44	981036	19236
1020x30	933,05	732,45	1144156	22434	1,10	685,77	1044891	20488
1020x32	993,25	779,7	1213210	23788	1,10	728,92	1107954	21724
1120x12	417,71	327,9	641079	11448	1,20	289,85	536468	9580
1120x14	486,44	381,86	743914	13284	1,20	335,00	622522	11116
1120x16	554,93	435,62	845626	15100	1,20	379,99	707637	12636
1120x18	623,17	489,19	946222	16897	1,20	424,82	791818	14140
1120x20	691,15	542,55	1045711	18673	1,20	469,47	875072	15626
1220x12	455,41	357,49	830778	13619	1,30	290,32	641527	10517
1220x14	530,43	416,38	964469	15811	1,30	335,79	744764	12209
1220x16	605,20	475,08	1096822	17981	1,30	381,12	846967	13885

Pipe characteristics					Combination with MF75 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
1220x18	679,71	533,58	1227844	20129	1,30	426,29	948142	15544
1220x20	753,98	591,88	1357545	22255	1,30	471,31	1048297	17185
1420x12	530,80	416,68	1315469	18528	1,50	291,07	879912	12393
1420x14	618,39	485,44	1528224	21524	1,50	337,06	1022223	14397
1420x16	705,73	554	1739152	24495	1,50	382,92	1163312	16385
1420x18	792,81	622,36	1948265	27440	1,50	428,65	1303187	18355
1420x20	879,65	690,52	2155572	30360	1,50	474,24	1441854	20308
1620x12	606,20	475,87	1959402	24190	1,70	291,65	1155989	14271
1620x14	706,36	554,49	2277496	28117	1,70	338,03	1343655	16588
1620x16	806,26	632,91	2593201	32015	1,70	384,29	1529912	18888
1620x18	905,91	711,14	2906530	35883	1,70	430,45	1714767	21170
1620x20	1005,31	789,17	3217494	39722	1,70	476,48	1898227	23435
1820x12	681,60	535,06	2785195	30607	1,90	292,10	1469760	16151
1820x14	794,32	623,54	3238674	35590	1,90	338,79	1709063	18781
1820x16	906,79	711,83	3689127	40540	1,90	385,38	1946769	21393
1820x18	1019,01	799,92	4136567	45457	1,90	431,87	2182885	23988
1820x20	1130,97	887,81	4581008	50341	1,90	478,25	2417418	26565
2020x12	757,00	594,24	3815468	37777	2,10	292,46	1821226	18032
2020x14	882,28	692,59	4438149	43942	2,10	339,41	2118448	20975
2020x16	1007,32	790,75	5057090	50070	2,10	386,26	2413885	23900
2020x18	1132,10	888,7	5672307	56161	2,10	433,02	2707545	26807
2020x20	1256,64	986,46	6283814	62216	2,10	479,68	2999434	29697

Table 9.1.3 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ 8943:2019 and MF100 connectors.

Pipe characteristics					Combination with MF100 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
820x10	254,47	199,76	208728	5091	0,92	239,46	226878	5534
820x12	304,61	239,12	248640	6064	0,92	282,24	270261	6591
820x14	354,50	278,28	287955	7023	0,92	324,81	312995	7634
820x16	404,13	317,25	326678	7968	0,92	367,17	355085	8661
820x18	453,52	356,01	364816	8898	0,92	409,30	396539	9672
820x20	502,65	394,58	402375	9814	0,92	451,22	437364	10667
820x22	551,54	432,96	439361	10716	0,92	492,94	477566	11648
820x24	600,17	471,13	475779	11604	0,92	534,43	517151	12613
820x26	648,55	509,11	511635	12479	0,92	575,71	556125	13564
820x28	696,68	546,89	546935	13340	0,92	616,78	594495	14500
820x30	744,56	584,48	581686	14187	0,92	657,64	632267	15421
920x10	285,88	224,42	295962	6434	1,02	240,16	290159	6308
920x12	342,31	268,71	352837	7670	1,02	283,58	345919	7520
920x14	398,48	312,81	408956	8890	1,02	326,82	400937	8716
920x16	454,40	356,7	464324	10094	1,02	369,85	455220	9896
920x18	510,07	400,4	518949	11282	1,02	412,69	508774	11061
920x20	565,49	443,91	572838	12453	1,02	455,35	561606	12209
1020x10	317,30	249,08	404638	7934	1,12	240,74	361284	7084
1020x12	380,01	298,31	482708	9465	1,12	284,69	430989	8451
1020x14	442,46	347,33	559843	10977	1,12	328,46	499860	9801
1020x16	504,67	396,16	636050	12472	1,12	372,06	567902	11136
1020x18	566,62	444,79	711337	13948	1,12	415,48	635122	12454
1020x20	628,32	493,23	785712	15406	1,12	458,73	701529	13755
1020x22	689,77	541,47	859182	16847	1,12	501,80	767127	15042
1020x24	750,97	589,51	931754	18270	1,12	544,69	831923	16313
1020x26	811,91	637,35	1003435	19675	1,12	587,41	895924	17567
1020x28	872,61	685	1074234	21063	1,12	629,95	959138	18806
1020x30	933,05	732,45	1144156	22434	1,12	672,32	1021568	20030
1020x32	993,25	779,7	1213210	23788	1,12	714,50	1083223	21239
1120x12	417,71	327,9	641079	11448	1,22	285,61	525475	9384
1120x14	486,44	381,86	743914	13284	1,22	329,84	609766	10889
1120x16	554,93	435,62	845626	15100	1,22	373,91	693136	12377
1120x18	623,17	489,19	946222	16897	1,22	417,82	775592	13850
1120x20	691,15	542,55	1045711	18673	1,22	461,55	857140	15306
1220x12	455,41	357,49	830778	13619	1,32	286,39	629377	10317
1220x14	530,43	416,38	964469	15811	1,32	331,00	730658	11978
1220x16	605,20	475,08	1096822	17981	1,32	375,47	830926	13622

Pipe characteristics					Combination with MF100 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
1220x18	679,71	533,58	1227844	20129	1,32	419,79	930185	15249
1220x20	753,98	591,88	1357545	22255	1,32	463,96	1028443	16860
1420x12	530,80	416,68	1315469	18528	1,52	287,65	865440	12189
1420x14	618,39	485,44	1528224	21524	1,52	332,88	1005411	14161
1420x16	705,73	554	1739152	24495	1,52	377,99	1144179	16115
1420x18	792,81	622,36	1948265	27440	1,52	422,96	1281753	18053
1420x20	879,65	690,52	2155572	30360	1,52	467,81	1418139	19974
1620x12	606,20	475,87	1959402	24190	1,72	288,61	1139187	14064
1620x14	706,36	554,49	2277496	28117	1,72	334,32	1324126	16347
1620x16	806,26	632,91	2593201	32015	1,72	379,92	1507675	18613
1620x18	905,91	711,14	2906530	35883	1,72	425,40	1689843	20862
1620x20	1005,31	789,17	3217494	39722	1,72	470,76	1870636	23094
1820x12	681,60	535,06	2785195	30607	1,92	289,38	1450622	15941
1820x14	794,32	623,54	3238674	35590	1,92	335,46	1686809	18536
1820x16	906,79	711,83	3689127	40540	1,92	381,45	1921420	21115
1820x18	1019,01	799,92	4136567	45457	1,92	427,33	2154462	23676
1820x20	1130,97	887,81	4581008	50341	1,92	473,10	2385942	26219
2020x12	757,00	594,24	3815468	37777	2,12	289,99	1799749	17819
2020x14	882,28	692,59	4438149	43942	2,12	336,38	2093467	20727
2020x16	1007,32	790,75	5057090	50070	2,12	382,69	2385420	23618
2020x18	1132,10	888,7	5672307	56161	2,12	428,89	2675617	26491
2020x20	1256,64	986,46	6283814	62216	2,12	475,00	2964063	29347

Table 9.1.4 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ 8943:2019 and MF130 connectors.

Pipe characteristics					Combination with MF130 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
820x10	254,47	199,76	208728	5091	0,95	234,82	219714	5359
820x12	304,61	239,12	248640	6064	0,95	276,25	261726	6383
820x14	354,50	278,28	287955	7023	0,95	317,47	303111	7393
820x16	404,13	317,25	326678	7968	0,95	358,49	343872	8387
820x18	453,52	356,01	364816	8898	0,95	399,29	384017	9366
820x20	502,65	394,58	402375	9814	0,95	439,89	423553	10331
820x22	551,54	432,96	439361	10716	0,95	480,29	462485	11280
820x24	600,17	471,13	475779	11604	0,95	520,47	500820	12215
820x26	648,55	509,11	511635	12479	0,95	560,45	538563	13136
820x28	696,68	546,89	546935	13340	0,95	600,22	575721	14042
820x30	744,56	584,48	581686	14187	0,95	639,79	612301	14934
920x10	285,88	224,42	295962	6434	1,05	235,94	281869	6128
920x12	342,31	268,71	352837	7670	1,05	278,12	336035	7305
920x14	398,48	312,81	408956	8890	1,05	320,12	389482	8467
920x16	454,40	356,7	464324	10094	1,05	361,92	442213	9613
920x18	510,07	400,4	518949	11282	1,05	403,54	494237	10745
920x20	565,49	443,91	572838	12453	1,05	444,98	545560	11860
1020x10	317,30	249,08	404638	7934	1,15	236,87	351859	6899
1020x12	380,01	298,31	482708	9465	1,15	279,68	419746	8230
1020x14	442,46	347,33	559843	10977	1,15	322,30	486820	9545
1020x16	504,67	396,16	636050	12472	1,15	364,76	553087	10845
1020x18	566,62	444,79	711337	13948	1,15	407,05	618554	12129
1020x20	628,32	493,23	785712	15406	1,15	449,17	683228	13397
1020x22	689,77	541,47	859182	16847	1,15	491,12	747115	14650
1020x24	750,97	589,51	931754	18270	1,15	532,89	810221	15887
1020x26	811,91	637,35	1003435	19675	1,15	574,49	872552	17109
1020x28	872,61	685	1074234	21063	1,15	615,93	934117	18316
1020x30	933,05	732,45	1144156	22434	1,15	657,19	994918	19508
1020x32	993,25	779,7	1213210	23788	1,15	698,28	1054965	20685
1120x12	417,71	327,9	641079	11448	1,25	280,98	512863	9158
1120x14	486,44	381,86	743914	13284	1,25	324,14	595131	10627
1120x16	554,93	435,62	845626	15100	1,25	367,15	676501	12080
1120x18	623,17	489,19	946222	16897	1,25	410,01	756978	13518
1120x20	691,15	542,55	1045711	18673	1,25	452,70	836569	14938
1220x12	455,41	357,49	830778	13619	1,35	282,08	615391	10088
1220x14	530,43	416,38	964469	15811	1,35	325,70	714421	11712
1220x16	605,20	475,08	1096822	17981	1,35	369,18	812461	13319

Pipe characteristics					Combination with MF130 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
1220x18	679,71	533,58	1227844	20129	1,35	412,52	909514	14910
1220x20	753,98	591,88	1357545	22255	1,35	455,70	1005589	16485
1420x12	530,80	416,68	1315469	18528	1,55	283,87	848690	11954
1420x14	618,39	485,44	1528224	21524	1,55	328,23	985951	13886
1420x16	705,73	554	1739152	24495	1,55	372,46	1122034	15803
1420x18	792,81	622,36	1948265	27440	1,55	416,57	1256945	17703
1420x20	879,65	690,52	2155572	30360	1,55	460,54	1390692	19587
1620x12	606,20	475,87	1959402	24190	1,75	285,25	1119658	13823
1620x14	706,36	554,49	2277496	28117	1,75	330,18	1301426	16067
1620x16	806,26	632,91	2593201	32015	1,75	374,99	1481829	18294
1620x18	905,91	711,14	2906530	35883	1,75	419,69	1660874	20505
1620x20	1005,31	789,17	3217494	39722	1,75	464,28	1838568	22698
1820x12	681,60	535,06	2785195	30607	1,95	286,35	1428305	15696
1820x14	794,32	623,54	3238674	35590	1,95	331,72	1660858	18251
1820x16	906,79	711,83	3689127	40540	1,95	377,00	1891860	20790
1820x18	1019,01	799,92	4136567	45457	1,95	422,17	2121316	23311
1820x20	1130,97	887,81	4581008	50341	1,95	467,25	2349235	25816
2020x12	757,00	594,24	3815468	37777	2,15	287,24	1774636	17571
2020x14	882,28	692,59	4438149	43942	2,15	332,98	2064255	20438
2020x16	1007,32	790,75	5057090	50070	2,15	378,64	2352135	23288
2020x18	1132,10	888,7	5672307	56161	2,15	424,19	2638282	26121
2020x20	1256,64	986,46	6283814	62216	2,15	469,66	2922704	28938

Table 9.1.5 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ 8943:2019 and MF180a connectors

Pipe characteristics					Combination with MF180a connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
820x10	254,47	199,76	208728	5091	1,00	227,94	208728	5091
820x12	304,61	239,12	248640	6064	1,00	267,30	248640	6064
820x14	354,50	278,28	287955	7023	1,00	306,46	287955	7023
820x16	404,13	317,25	326678	7968	1,00	345,43	326678	7968
820x18	453,52	356,01	364816	8898	1,00	384,19	364816	8898
820x20	502,65	394,58	402375	9814	1,00	422,76	402375	9814
820x22	551,54	432,96	439361	10716	1,00	461,14	439361	10716
820x24	600,17	471,13	475779	11604	1,00	499,31	475779	11604
820x26	648,55	509,11	511635	12479	1,00	537,29	511635	12479
820x28	696,68	546,89	546935	13340	1,00	575,07	546935	13340
820x30	744,56	584,48	581686	14187	1,00	612,66	581686	14187
920x10	285,88	224,42	295962	6434	1,10	229,64	269056	5849
920x12	342,31	268,71	352837	7670	1,10	269,90	320761	6973
920x14	398,48	312,81	408956	8890	1,10	309,99	371778	8082
920x16	454,40	356,7	464324	10094	1,10	349,89	422113	9176
920x18	510,07	400,4	518949	11282	1,10	389,62	471772	10256
920x20	565,49	443,91	572838	12453	1,10	429,17	520762	11321
1020x10	317,30	249,08	404638	7934	1,20	231,05	337198	6612
1020x12	380,01	298,31	482708	9465	1,20	272,07	402257	7888
1020x14	442,46	347,33	559843	10977	1,20	312,92	466536	9148
1020x16	504,67	396,16	636050	12472	1,20	353,62	530042	10393
1020x18	566,62	444,79	711337	13948	1,20	394,14	592781	11623
1020x20	628,32	493,23	785712	15406	1,20	434,51	654760	12838
1020x22	689,77	541,47	859182	16847	1,20	474,71	715985	14039
1020x24	750,97	589,51	931754	18270	1,20	514,74	776462	15225
1020x26	811,91	637,35	1003435	19675	1,20	554,61	836196	16396
1020x28	872,61	685	1074234	21063	1,20	594,32	895195	17553
1020x30	933,05	732,45	1144156	22434	1,20	633,86	953463	18695
1020x32	993,25	779,7	1213210	23788	1,20	673,23	1011008	19823
1120x12	417,71	327,9	641079	11448	1,30	273,91	493138	8806
1120x14	486,44	381,86	743914	13284	1,30	315,41	572242	10218
1120x16	554,93	435,62	845626	15100	1,30	356,77	650482	11615
1120x18	623,17	489,19	946222	16897	1,30	397,98	727863	12998
1120x20	691,15	542,55	1045711	18673	1,30	439,02	804393	14364
1220x12	455,41	357,49	830778	13619	1,40	275,48	593413	9728
1220x14	530,43	416,38	964469	15811	1,40	317,54	688906	11294
1220x16	605,20	475,08	1096822	17981	1,40	359,47	783444	12844

Pipe characteristics					Combination with MF180a connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
1220x18	679,71	533,58	1227844	20129	1,40	401,26	877031	14378
1220x20	753,98	591,88	1357545	22255	1,40	442,90	969675	15896
1420x12	530,80	416,68	1315469	18528	1,60	278,04	822168	11580
1420x14	618,39	485,44	1528224	21524	1,60	321,01	955140	13453
1420x16	705,73	554	1739152	24495	1,60	363,86	1086970	15309
1420x18	792,81	622,36	1948265	27440	1,60	406,59	1217666	17150
1420x20	879,65	690,52	2155572	30360	1,60	449,19	1347233	18975
1620x12	606,20	475,87	1959402	24190	1,80	280,03	1088557	13439
1620x14	706,36	554,49	2277496	28117	1,80	323,70	1265276	15621
1620x16	806,26	632,91	2593201	32015	1,80	367,27	1440667	17786
1620x18	905,91	711,14	2906530	35883	1,80	410,73	1614739	19935
1620x20	1005,31	789,17	3217494	39722	1,80	454,08	1787497	22068
1820x12	681,60	535,06	2785195	30607	2,00	281,62	1392598	15304
1820x14	794,32	623,54	3238674	35590	2,00	325,86	1619337	17795
1820x16	906,79	711,83	3689127	40540	2,00	370,00	1844564	20270
1820x18	1019,01	799,92	4136567	45457	2,00	414,05	2068284	22729
1820x20	1130,97	887,81	4581008	50341	2,00	457,99	2290504	25171
2020x12	757,00	594,24	3815468	37777	2,20	282,92	1734304	17171
2020x14	882,28	692,59	4438149	43942	2,20	327,62	2017340	19974
2020x16	1007,32	790,75	5057090	50070	2,20	372,24	2298677	22759
2020x18	1132,10	888,7	5672307	56161	2,20	416,76	2578321	25528
2020x20	1256,64	986,46	6283814	62216	2,20	461,20	2856279	28280

Table 9.1.6 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ 8943:2019 and MF180b connectors.

Pipe characteristics					Combination with MF180b connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm2**	**G**	**I, cm4**	**W, cm3**	**bsys,m**	**G97%**	**Isys, cm4**	**Wsys,cm3**
820x10	254,47	199,76	208728	5091	1,00	227,09	208728	5091
820x12	304,61	239,12	248640	6064	1,00	266,45	248640	6064
820x14	354,50	278,28	287955	7023	1,00	305,61	287955	7023
820x16	404,13	317,25	326678	7968	1,00	344,58	326678	7968
820x18	453,52	356,01	364816	8898	1,00	383,34	364816	8898
820x20	502,65	394,58	402375	9814	1,00	421,91	402375	9814
820x22	551,54	432,96	439361	10716	1,00	460,29	439361	10716
820x24	600,17	471,13	475779	11604	1,00	498,46	475779	11604
820x26	648,55	509,11	511635	12479	1,00	536,44	511635	12479
820x28	696,68	546,89	546935	13340	1,00	574,22	546935	13340
820x30	744,56	584,48	581686	14187	1,00	611,81	581686	14187
920x10	285,88	224,42	295962	6434	1,10	228,87	269056	5849
920x12	342,31	268,71	352837	7670	1,10	269,13	320761	6973
920x14	398,48	312,81	408956	8890	1,10	309,22	371778	8082
920x16	454,40	356,7	464324	10094	1,10	349,12	422113	9176
920x18	510,07	400,4	518949	11282	1,10	388,85	471772	10256
920x20	565,49	443,91	572838	12453	1,10	428,40	520762	11321
1020x10	317,30	249,08	404638	7934	1,20	230,35	337198	6612
1020x12	380,01	298,31	482708	9465	1,20	271,37	402257	7888
1020x14	442,46	347,33	559843	10977	1,20	312,22	466536	9148
1020x16	504,67	396,16	636050	12472	1,20	352,91	530042	10393
1020x18	566,62	444,79	711337	13948	1,20	393,44	592781	11623
1020x20	628,32	493,23	785712	15406	1,20	433,80	654760	12838
1020x22	689,77	541,47	859182	16847	1,20	474,00	715985	14039
1020x24	750,97	589,51	931754	18270	1,20	514,04	776462	15225
1020x26	811,91	637,35	1003435	19675	1,20	553,90	836196	16396
1020x28	872,61	685	1074234	21063	1,20	593,61	895195	17553
1020x30	933,05	732,45	1144156	22434	1,20	633,15	953463	18695
1020x32	993,25	779,7	1213210	23788	1,20	672,53	1011008	19823
1120x12	417,71	327,9	641079	11448	1,30	273,26	493138	8806
1120x14	486,44	381,86	743914	13284	1,30	314,77	572242	10218
1120x16	554,93	435,62	845626	15100	1,30	356,12	650482	11615
1120x18	623,17	489,19	946222	16897	1,30	397,33	727863	12998
1120x20	691,15	542,55	1045711	18673	1,30	438,37	804393	14364
1220x12	455,41	357,49	830778	13619	1,40	274,87	593413	9728
1220x14	530,43	416,38	964469	15811	1,40	316,94	688906	11294

Pipe characteristics					Combination with MF180b connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm2**	**G**	**I, cm4**	**W, cm3**	**bsys,m**	**G97%**	**Isys, cm4**	**Wsys,cm3**
1220x16	605,20	475,08	1096822	17981	1,40	358,87	783444	12844
1220x18	679,71	533,58	1227844	20129	1,40	400,65	877031	14378
1220x20	753,98	591,88	1357545	22255	1,40	442,30	969675	15896
1420x12	530,80	416,68	1315469	18528	1,60	277,51	822168	11580
1420x14	618,39	485,44	1528224	21524	1,60	320,48	955140	13453
1420x16	705,73	554	1739152	24495	1,60	363,33	1086970	15309
1420x18	792,81	622,36	1948265	27440	1,60	406,06	1217666	17150
1420x20	879,65	690,52	2155572	30360	1,60	448,66	1347233	18975
1620x12	606,20	475,87	1959402	24190	1,80	279,56	1088557	13439
1620x14	706,36	554,49	2277496	28117	1,80	323,24	1265276	15621
1620x16	806,26	632,91	2593201	32015	1,80	366,80	1440667	17786
1620x18	905,91	711,14	2906530	35883	1,80	410,26	1614739	19935
1620x20	1005,31	789,17	3217494	39722	1,80	453,61	1787497	22068
1820x12	681,60	535,06	2785195	30607	2,00	281,20	1392598	15304
1820x14	794,32	623,54	3238674	35590	2,00	325,44	1619337	17795
1820x16	906,79	711,83	3689127	40540	2,00	369,58	1844564	20270
1820x18	1019,01	799,92	4136567	45457	2,00	413,63	2068284	22729
1820x20	1130,97	887,81	4581008	50341	2,00	457,57	2290504	25171
2020x12	757,00	594,24	3815468	37777	2,20	282,53	1734304	17171
2020x14	882,28	692,59	4438149	43942	2,20	327,24	2017340	19974
2020x16	1007,32	790,75	5057090	50070	2,20	371,86	2298677	22759
2020x18	1132,10	888,7	5672307	56161	2,20	416,38	2578321	25528
2020x20	1256,64	986,46	6283814	62216	2,20	460,82	2856279	28280

Table 9.1.7 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ 8943:2019 and MF230 connectors.

Pipe characteristics					Combination with MF230 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
820x10	254,47	199,76	208728	5091	1,05	220,91	198789	4849
820x12	304,61	239,12	248640	6064	1,05	258,39	236800	5775
820x14	354,50	278,28	287955	7023	1,05	295,69	274243	6689
820x16	404,13	317,25	326678	7968	1,05	332,80	311122	7589
820x18	453,52	356,01	364816	8898	1,05	369,72	347444	8474
820x20	502,65	394,58	402375	9814	1,05	406,45	383214	9347
820x22	551,54	432,96	439361	10716	1,05	443,00	418439	10206
820x24	600,17	471,13	475779	11604	1,05	479,36	453123	11051
820x26	648,55	509,11	511635	12479	1,05	515,53	487271	11885
820x28	696,68	546,89	546935	13340	1,05	551,51	520890	12705
820x30	744,56	584,48	581686	14187	1,05	587,31	553987	13511
920x10	285,88	224,42	295962	6434	1,15	223,14	257358	5595
920x12	342,31	268,71	352837	7670	1,15	261,66	306815	6670
920x14	398,48	312,81	408956	8890	1,15	300,00	355614	7730
920x16	454,40	356,7	464324	10094	1,15	338,17	403760	8777
920x18	510,07	400,4	518949	11282	1,15	376,17	451260	9810
920x20	565,49	443,91	572838	12453	1,15	414,00	498120	10829
1020x10	317,30	249,08	404638	7934	1,25	225,02	323710	6347
1020x12	380,01	298,31	482708	9465	1,25	264,40	386166	7572
1020x14	442,46	347,33	559843	10977	1,25	303,62	447874	8782
1020x16	504,67	396,16	636050	12472	1,25	342,68	508840	9978
1020x18	566,62	444,79	711337	13948	1,25	381,59	569070	11158
1020x20	628,32	493,23	785712	15406	1,25	420,34	628570	12325
1020x22	689,77	541,47	859182	16847	1,25	458,93	687346	13478
1020x24	750,97	589,51	931754	18270	1,25	497,36	745403	14616
1020x26	811,91	637,35	1003435	19675	1,25	535,64	802748	15740
1020x28	872,61	685	1074234	21063	1,25	573,76	859387	16850
1020x30	933,05	732,45	1144156	22434	1,25	611,72	915325	17947
1020x32	993,25	779,7	1213210	23788	1,25	649,52	970568	19030
1120x12	417,71	327,9	641079	11448	1,35	266,74	474873	8480
1120x14	486,44	381,86	743914	13284	1,35	306,71	551047	9840
1120x16	554,93	435,62	845626	15100	1,35	346,53	626390	11185
1120x18	623,17	489,19	946222	16897	1,35	386,21	700905	12516
1120x20	691,15	542,55	1045711	18673	1,35	425,74	774601	13832
1220x12	455,41	357,49	830778	13619	1,45	268,75	572950	9392
1220x14	530,43	416,38	964469	15811	1,45	309,36	665151	10904
1220x16	605,20	475,08	1096822	17981	1,45	349,84	756429	12401

Pipe characteristics					Combination with MF230 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
1220x18	679,71	533,58	1227844	20129	1,45	390,19	846789	13882
1220x20	753,98	591,88	1357545	22255	1,45	430,40	936238	15348
1420x12	530,80	416,68	1315469	18528	1,65	272,05	797254	11229
1420x14	618,39	485,44	1528224	21524	1,65	313,72	926196	13045
1420x16	705,73	554	1739152	24495	1,65	355,27	1054032	14845
1420x18	792,81	622,36	1948265	27440	1,65	396,70	1180767	16630
1420x20	879,65	690,52	2155572	30360	1,65	438,01	1306407	18400
1620x12	606,20	475,87	1959402	24190	1,85	274,63	1059136	13076
1620x14	706,36	554,49	2277496	28117	1,85	317,13	1231079	15198
1620x16	806,26	632,91	2593201	32015	1,85	359,52	1401730	17305
1620x18	905,91	711,14	2906530	35883	1,85	401,80	1571097	19396
1620x20	1005,31	789,17	3217494	39722	1,85	443,98	1739186	21471
1820x12	681,60	535,06	2785195	30607	2,05	276,71	1358632	14930
1820x14	794,32	623,54	3238674	35590	2,05	319,87	1579841	17361
1820x16	906,79	711,83	3689127	40540	2,05	362,94	1799574	19776
1820x18	1019,01	799,92	4136567	45457	2,05	405,91	2017838	22174
1820x20	1130,97	887,81	4581008	50341	2,05	448,78	2234638	24557
2020x12	757,00	594,24	3815468	37777	2,25	278,42	1695764	16790
2020x14	882,28	692,59	4438149	43942	2,25	322,13	1972511	19530
2020x16	1007,32	790,75	5057090	50070	2,25	365,75	2247596	22253
2020x18	1132,10	888,7	5672307	56161	2,25	409,29	2521025	24960
2020x20	1256,64	986,46	6283814	62216	2,25	452,74	2792806	27652

9.2 Attachment 2. Characteristics of pipe sheet piles made of pipes in compliance with State Standard of Ukraine ДСТУ EN 10219-2:2009

This Attachment includes Tables 9.2.1…9.2.7 containing the characteristics of the pipe sheet pile and data for application of the connectors: MF63, MF75, MF100, MF130, MF180a, MF180 b, and MF 230.

Table 9.2.1 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ EN 10219-2:2009 and MF63 connectors.

Pipe characteristics					**Combination with MF63 connector**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800x10	248,19	194,83	193647	4841	0,86	243,84	224388	5610
900x10	279,60	219,49	276876	6153	0,96	289,29	287514	6389
1000x10	311,02	244,15	381074	7621	1,06	334,56	358489	7169
813×10	252,27	198,03	203364	5003	0,88	243,18	232151	5711
813×12	301,97	237,05	242235	5959	0,88	287,72	276524	6803
813×12,2	314,36	246,77	251860	6196	0,88	298,82	287511	7073
914×10	284,00	222,94	290147	6349	0,98	243,54	296977	6498
914×12	340,05	266,94	345890	7569	0,98	288,57	354033	7747
914×12,2	354,02	277,90	359708	7871	0,98	299,79	368176	8056
1016×10	316,04	248,09	399850	7871	1,08	243,82	370575	7295
1016×12	378,50	297,12	476985	9389	1,08	289,26	442062	8702
1016×12,5	394,07	309,35	496123	9766	1,08	300,60	459799	9051
1016×16	502,65	394,58	628479	12372	1,08	379,59	582464	11466
1016×20	625,81	491,26	776324	15282	1,08	469,19	719485	14163
1067×12	397,73	312,21	553420	10373	1,13	289,56	489752	9180
1067×12,5	414,10	325,07	575666	10790	1,13	300,94	509439	9549
1067×16	528,29	414,71	729606	13676	1,13	380,27	645669	12103
1067×20	657,85	516,41	901755	16903	1,13	470,27	798013	14958
1068×12	398,10	312,51	554995	10393	1,13	289,57	490712	9189
1068×12,5	414,49	325,38	577305	10811	1,13	300,95	510438	9559
1068×16	528,79	415,10	731691	13702	1,13	380,28	646942	12115
1068×20	658,48	516,91	904340	16935	1,13	470,30	799593	14973
1219×12	455,03	357,20	828716	13597	1,28	290,32	646424	10606
1219×12,5	473,79	371,93	862181	14146	1,28	301,81	672528	11034
1219×16	604,69	474,68	1094091	17951	1,28	381,96	853425	14002
1219×20	753,35	591,38	1354155	22217	1,28	472,99	1056283	17330

Table 9.2.2 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ EN 10219-2:2009 and MF75 connectors.

Pipe characteristics					**Combination with MF75 connector**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,83	193647	4841	0,88	243,77	221311	5533
900×10	279,60	219,49	276876	6153	0,98	244,1	283975	6311
1000×10	311,02	244,15	381074	7621	1,08	244,3	354487	7089
813×10	252,27	198,03	203364	5003	0,89	243,8	229014	5634
813×12	301,97	237,05	242235	5959	0,89	287,7	272787	6711
813×12,2	314,36	246,77	251860	6196	0,89	298,7	283626	6977
914×10	284,00	222,94	290147	6349	0,99	244,1	293374	6420
914×12	340,05	266,94	345890	7569	0,99	288,6	349737	7653
914×12,2	354,02	277,90	359708	7871	0,99	299,7	363709	7959
1016×10	316,04	248,09	399850	7871	1,09	244,3	366499	7214
1016×12	378,50	297,12	476985	9389	1,09	289,3	437200	8606
1016×12,5	394,07	309,35	496123	9766	1,09	300,5	454742	8951
1016×16	502,65	394,58	628479	12372	1,09	378,6	576058	11340
1016×20	625,81	491,26	776324	15282	1,09	467,2	711571	14007
1067×12	397,73	312,21	553420	10373	1,14	289,6	484606	9083
1067×12,5	414,10	325,07	575666	10790	1,14	300,8	504086	9448
1067×16	528,29	414,71	729606	13676	1,14	379,3	638884	11975
1067×20	657,85	516,41	901755	16903	1,14	468,4	789628	14801
1068×12	398,10	312,51	554995	10393	1,14	289,6	485560	9093
1068×12,5	414,49	325,38	577305	10811	1,14	300,8	505079	9458
1068×16	528,79	415,10	731691	13702	1,14	379,3	640150	11988
1068×20	658,48	516,91	904340	16935	1,14	468,4	791199	14816
1219×12	455,03	357,20	828716	13597	1,29	290,3	640430	10508
1219×12,5	473,79	371,93	862181	14146	1,29	301,7	666291	10932
1219×16	604,69	474,68	1094091	17951	1,29	381,1	845511	13872
1219×20	753,35	591,38	1354155	22217	1,29	471,3	1046488	17169

Table 9.2.3. Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ EN 10219-2:2009 and MF100 connectors.

Pipe characteristics					**Combination with MF100 connector**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,83	193647	4841	0,90	239,31	215163	5379
900×10	279,60	219,49	276876	6153	1,00	240,03	276876	6153
1000×10	311,02	244,15	381074	7621	1,10	240,63	346431	6928
813×10	252,27	198,03	203364	5003	0,91	239,40	222743	5480
813×12	301,97	237,05	242235	5959	0,91	282,14	265318	6527
813×12,2	314,36	246,77	251860	6196	0,91	292,79	275860	6786
914×10	284,00	222,94	290147	6349	1,01	240,12	286141	6261
914×12	340,05	266,94	345890	7569	1,01	283,52	341114	7464
914×12,2	354,02	277,90	359708	7871	1,01	294,32	354742	7762
1016×10	316,04	248,09	399850	7871	1,12	240,71	358289	7053
1016×12	378,50	297,12	476985	9389	1,12	284,65	427406	8413
1016×12,5	394,07	309,35	496123	9766	1,12	295,60	444555	8751
1016×16	502,65	394,58	628479	12372	1,12	371,98	563153	11086
1016×20	625,81	491,26	776324	15282	1,12	458,61	695631	13694
1067×12	397,73	312,21	553420	10373	1,17	285,14	474225	8889
1067×12,5	414,10	325,07	575666	10790	1,17	296,16	493287	9246
1067×16	528,29	414,71	729606	13676	1,17	372,97	625198	11719
1067×20	657,85	516,41	901755	16903	1,17	460,12	772712	14484
1068×12	398,10	312,51	554995	10393	1,17	285,15	475167	8898
1068×12,5	414,49	325,38	577305	10811	1,17	296,17	494268	9256
1068×16	528,79	415,10	731691	13702	1,17	372,98	626448	11731
1068×20	658,48	516,91	904340	16935	1,17	460,15	774264	14499
1219×12	455,03	357,20	828716	13597	1,32	286,39	628291	10309
1219×12,5	473,79	371,93	862181	14146	1,32	297,55	653663	10725
1219×16	604,69	474,68	1094091	17951	1,32	375,45	829485	13610
1219×20	753,35	591,38	1354155	22217	1,32	463,93	1026653	16844

Table 9.2.4 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ EN 10219-2:2009 and MF130 connectors.

Pipe characteristics					**Combination with MF130 connector**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, $1m^2$,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,83	193647	4841	0,93	234,57	208223	5205
900×10	279,60	219,49	276876	6153	1,03	235,74	268812	5974
1000×10	311,02	244,15	381074	7621	1,13	236,70	337234	6744
813×10	252,27	198,03	203364	5003	0,94	234,73	215656	5305
813×12	301,97	237,05	242235	5959	0,94	276,11	256877	6319
813×12,2	314,36	246,77	251860	6196	0,94	286,41	267084	6571
914×10	284,00	222,94	290147	6349	1,04	235,88	277919	6081
914×12	340,05	266,94	345890	7569	1,04	278,03	331312	7250
914×12,2	354,02	277,90	359708	7871	1,04	288,52	344548	7539
1016×10	316,04	248,09	399850	7871	1,15	236,83	348909	6868
1016×12	378,50	297,12	476985	9389	1,15	279,62	416217	8193
1016×12,5	394,07	309,35	496123	9766	1,15	290,29	432917	8522
1016×16	502,65	394,58	628479	12372	1,15	364,66	548411	10796
1016×20	625,81	491,26	776324	15282	1,15	449,02	677421	13335
1067×12	397,73	312,21	553420	10373	1,20	280,31	462339	8666
1067×12,5	414,10	325,07	575666	10790	1,20	291,05	480924	9014
1067×16	528,29	414,71	729606	13676	1,20	365,94	609529	11425
1067×20	657,85	516,41	901755	16903	1,20	450,90	753346	14121
1068×12	398,10	312,51	554995	10393	1,20	280,32	463268	8675
1068×12,5	414,49	325,38	577305	10811	1,20	291,07	481891	9024
1068×16	528,79	415,10	731691	13702	1,20	365,96	610760	11437
1068×20	658,48	516,91	904340	16935	1,20	450,94	754875	14136
1219×12	455,03	357,20	828716	13597	1,35	282,07	614319	10079
1219×12,5	473,79	371,93	862181	14146	1,35	292,99	639126	10486
1219×16	604,69	474,68	1094091	17951	1,35	369,16	811039	13307
1219×20	753,35	591,38	1354155	22217	1,35	455,67	1003821	16469

Table 9.2.5 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ EN 10219-2:2009 and MF180a connectors.

Pipe characteristics					**Combination with MF180a connector**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	A,cm^2	G	I, cm^4	W, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
800×10	248,19	194,83	193647	4841	0,98	227,56	197599	4940
900×10	279,60	219,49	276876	6153	1,08	229,32	256367	5697
1000×10	311,02	244,15	381074	7621	1,18	230,79	322944	6458
813×10	252,27	198,03	203364	5003	0,99	227,80	204798	5038
813×12	301,97	237,05	242235	5959	0,99	267,10	243943	6001
813×12,2	314,36	246,77	251860	6196	0,99	276,89	253635	6240
914×10	284,00	222,94	290147	6349	1,09	229,54	265217	5803
914×12	340,05	266,94	345890	7569	1,09	269,76	316170	6919
914×12,2	354,02	277,90	359708	7871	1,09	279,78	328801	7195
1016×10	316,04	248,09	399850	7871	1,20	230,99	334323	6581
1016×12	378,50	297,12	476985	9389	1,20	271,99	398817	7850
1016×12,5	394,07	309,35	496123	9766	1,20	282,21	414819	8166
1016×16	502,65	394,58	628479	12372	1,20	353,48	525484	10344
1016×20	625,81	491,26	776324	15282	1,20	434,31	649100	12778
1067×12	397,73	312,21	553420	10373	1,25	272,97	443801	8318
1067×12,5	414,10	325,07	575666	10790	1,25	283,28	461641	8653
1067×16	528,29	414,71	729606	13676	1,25	355,16	585089	10967
1067×20	657,85	516,41	901755	16903	1,25	436,72	723140	13555
1068×12	398,10	312,51	554995	10393	1,25	272,99	444708	8328
1068×12,5	414,49	325,38	577305	10811	1,25	283,30	462584	8663
1068×16	528,79	415,10	731691	13702	1,25	355,19	586291	10979
1068×20	658,48	516,91	904340	16935	1,25	436,77	724631	13570
1219×12	455,03	357,20	828716	13597	1,40	275,47	592363	9719
1219×12,5	473,79	371,93	862181	14146	1,40	286,00	616284	10112
1219×16	604,69	474,68	1094091	17951	1,40	359,44	782052	12831
1219×20	753,35	591,38	1354155	22217	1,40	442,86	967945	15881

Table 9.2.6 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ EN 10219-2:2009 and MF180b connectors.

Pipe characteristics					**Комбінація з конектором MF180 b**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800x10	248,19	194,83	193647	4841	0,98	226,70	197599	4940
900x10	279,60	219,49	276876	6153	1,08	228,54	256367	5697
1000x10	311,02	244,15	381074	7621	1,18	230,07	322944	6458
813×10	252,27	198,03	203364	5003	0,99	226,95	204798	5038
813×12	301,97	237,05	242235	5959	0,99	266,25	243943	6001
813×12,2	314,36	246,77	251860	6196	0,99	276,04	253635	6240
914×10	284,00	222,94	290147	6349	1,09	228,77	265217	5803
914×12	340,05	266,94	345890	7569	1,09	268,99	316170	6919
914×12,2	354,02	277,90	359708	7871	1,09	279,01	328801	7195
1016×10	316,04	248,09	399850	7871	1,20	230,29	334323	6581
1016×12	378,50	297,12	476985	9389	1,20	271,28	398817	7850
1016×12,5	394,07	309,35	496123	9766	1,20	281,51	414819	8166
1016×16	502,65	394,58	628479	12372	1,20	352,77	525484	10344
1016×20	625,81	491,26	776324	15282	1,20	433,61	649100	12778
1067×12	397,73	312,21	553420	10373	1,25	272,29	443801	8318
1067×12,5	414,10	325,07	575666	10790	1,25	282,60	461641	8653
1067×16	528,29	414,71	729606	13676	1,25	354,49	585089	10967
1067×20	657,85	516,41	901755	16903	1,25	436,04	723140	13555
1068×12	398,10	312,51	554995	10393	1,25	272,31	444708	8328
1068×12,5	414,49	325,38	577305	10811	1,25	282,62	462584	8663
1068×16	528,79	415,10	731691	13702	1,25	354,51	586291	10979
1068×20	658,48	516,91	904340	16935	1,25	436,09	724631	13570
1219×12	455,03	357,20	828716	13597	1,40	274,86	592363	9719
1219×12,5	473,79	371,93	862181	14146	1,40	285,39	616284	10112
1219×16	604,69	474,68	1094091	17951	1,40	358,84	782052	12831
1219×20	753,35	591,38	1354155	22217	1,40	442,25	967945	15881

Table 9.2.7 Characteristics of pipe sheet piles, using pipes in compliance with State Standard of Ukraine ДСТУ EN 10219-2:2009 and MF230 connectors.

Pipe characteristics					**Combination with MF230 connector**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm2**	**G**	**I, cm4**	**W, cm3**	**bsys,m**	**G97%**	**Isys, cm4**	**Wsys,cm3**
800x10	248,19	194,83	193647	4841	1,03	220,41	188007	4700
900x10	279,60	219,49	276876	6153	1,13	222,73	245023	5445
1000x10	311,02	244,15	381074	7621	1,23	224,67	309816	6196
813×10	252,27	198,03	203364	5003	1,04	220,73	194980	4797
813×12	301,97	237,05	242235	5959	1,04	258,14	232248	5713
813×12,2	314,36	246,77	251860	6196	1,04	267,46	241477	5941
914×10	284,00	222,94	290147	6349	1,14	223,02	253625	5550
914×12	340,05	266,94	345890	7569	1,14	261,48	302351	6616
914×12,2	354,02	277,90	359708	7871	1,14	271,06	314430	6880
1016×10	316,04	248,09	399850	7871	1,25	224,95	320907	6317
1016×12	378,50	297,12	476985	9389	1,25	264,30	382813	7535
1016×12,5	394,07	309,35	496123	9766	1,25	274,11	398173	7838
1016×16	502,65	394,58	628479	12372	1,25	342,52	504397	9929
1016×20	625,81	491,26	776324	15282	1,25	420,11	623053	12265
1067×12	397,73	312,21	553420	10373	1,30	265,54	426692	7998
1067×12,5	414,10	325,07	575666	10790	1,30	275,45	443844	8319
1067×16	528,29	414,71	729606	13676	1,30	344,57	562534	10544
1067×20	657,85	516,41	901755	16903	1,30	422,98	695262	13032
1068×12	398,10	312,51	554995	10393	1,30	265,57	427577	8007
1068×12,5	414,49	325,38	577305	10811	1,30	275,48	444765	8329
1068×16	528,79	415,10	731691	13702	1,30	344,60	563706	10556
1068×20	658,48	516,91	904340	16935	1,30	423,04	696718	13047
1219×12	455,03	357,20	828716	13597	1,45	268,73	571923	9384
1219×12,5	473,79	371,93	862181	14146	1,45	278,90	595018	9763
1219×16	604,69	474,68	1094091	17951	1,45	349,81	755066	12389
1219×20	753,35	591,38	1354155	22217	1,45	430,35	934545	15333

9.3 Attachment 3. Characteristics of pipe sheet piles made of pipes in compliance with EN

This Attachment includes tables 9.3.1…9.3.7 containing the characteristics of the pipe sheet pile and data for application of the connectors MF63, MF75, MF100, MF130, MF180a, MF180 b, MF 230.

Table 9.3.1 Characteristics of pipe sheet piles, using pipes in compliance with EN and MF63 connectors.

Pipe characteristics					**Combination with MF63 connector**			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,8	193647	4841	0,86	243,14	224388	5610
800×12	297,07	233,2	230632	5766	0,86	287,60	267244	6681
900×10	279,60	219,5	276876	6153	0,96	243,50	287514	6389
900×12	334,77	262,8	330034	7334	0,96	288,46	342714	7616
1000×10	311,02	244,2	381074	7621	1,06	243,79	358489	7169
1000×12	372,47	292,4	454544	9091	1,06	289,17	427605	8552
1100×13	443,94	348,5	655774	11923	1,16	312,54	563864	10252
1200×13	484,78	380,6	853901	14232	1,26	313,18	676089	11268
1200×14	521,63	409,5	917281	15288	1,26	336,09	726272	12105
1300×15	605,54	475,4	1250028	19231	1,36	359,76	917115	14109
1400×16	695,67	546,1	1665889	23798	1,46	383,52	1138680	16267
1500×17	792,03	621,7	2177656	29035	1,56	407,38	1393254	18576
1600×18	894,60	702,3	2799033	34988	1,66	431,30	1683123	21039
1700×19	1003,39	787,7	3544640	41702	1,76	455,28	2010573	23654
1800×20	1118,41	878,0	4430010	49222	1,86	479,31	2377890	26421
1900×21	1239,64	973,1	5471593	57596	1,96	503,37	2787363	29341
2000×22	1367,10	1073,2	6686751	66868	2,06	527,47	3241275	32413
2100×23	1500,77	1178,1	8093763	77083	2,16	551,59	3741915	35637
2200×24	1640,67	1287,9	9711820	88289	2,26	575,75	4291569	39014
2300×25	1786,78	1402,6	11561030	100531	2,36	599,92	4892522	42544
2400×25	1865,32	1464,3	13153425	109612	2,46	600,60	5340408	44503
2500×25	1943,86	1525,9	14885719	119086	2,56	601,22	5807928	46464
2500×26	2020,80	1586,3	15462520	123700	2,56	624,79	6032977	48264

Table 9.3.2. Characteristics of pipe sheet piles, using pipes in compliance with EN and MF75 connectors.

Pipe characteristics					Combination with MF75 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,8	193647	4841	0,88	243,77	221311	5533
800×12	297,07	233,2	230632	5766	0,88	287,62	263579	6590
900×10	279,60	219,5	276876	6153	0,98	244,06	283975	6311
900×12	334,77	262,8	330034	7334	0,98	288,47	338496	7522
1000×10	311,02	244,2	381074	7621	1,08	244,30	354487	7089
1000×12	372,47	292,4	454544	9091	1,08	289,17	422832	8457
1100×13	443,94	348,5	655774	11923	1,18	312,31	558106	10147
1200×13	484,78	380,6	853901	14232	1,28	312,96	669726	11162
1200×14	521,63	409,5	917281	15288	1,28	335,65	719436	11991
1300×15	605,54	475,4	1250028	19231	1,38	359,14	909111	13986
1400×16	695,67	546,1	1665889	23798	1,48	382,76	1129416	16134
1500×17	792,03	621,7	2177656	29035	1,58	406,48	1382639	18435
1600×18	894,60	702,3	2799033	34988	1,68	430,29	1671064	20888
1700×19	1003,39	787,7	3544640	41702	1,78	454,16	1996980	23494
1800×20	1118,41	878,0	4430010	49222	1,88	478,09	2362672	26252
1900×21	1239,64	973,1	5471593	57596	1,98	502,07	2770427	29163
2000×22	1367,10	1073,2	6686751	66868	2,08	526,09	3222531	32226
2100×23	1500,77	1178,1	8093763	77083	2,18	550,15	3721270	35440
2200×24	1640,67	1287,9	9711820	88289	2,28	574,24	4268932	38808
2300×25	1786,78	1402,6	11561030	100531	2,38	598,35	4867802	42329
2400×25	1865,32	1464,3	13153425	109612	2,48	599,09	5314515	44288
2500×25	1943,86	1525,9	14885719	119086	2,58	599,77	5780862	46247
2500×26	2020,80	1586,3	15462520	123700	2,58	623,22	6004862	48039

Table 9.3.3 Characteristics of pipe sheet piles, using pipes in compliance with EN and MF100 connectors.

Pipe characteristics					Combination with MF100 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,8	193647	4841	0,90	239,31	215163	5379
800×12	297,07	233,2	230632	5766	0,90	281,94	256258	6407
900×10	279,60	219,5	276876	6153	1,00	240,03	276876	6153
900×12	334,77	262,8	330034	7334	1,00	283,33	330034	7334
1000×10	311,02	244,2	381074	7621	1,10	240,63	346431	6928
1000×12	372,47	292,4	454544	9091	1,10	284,49	413222	8265
1100×13	443,94	348,5	655774	11923	1,20	307,53	546478	9936
1200×13	484,78	380,6	853901	14232	1,30	308,53	656847	10948
1200×14	521,63	409,5	917281	15288	1,30	330,79	705601	11760
1300×15	605,54	475,4	1250028	19231	1,40	354,21	892877	13736
1400×16	695,67	546,1	1665889	23798	1,50	377,76	1110593	15865
1500×17	792,03	621,7	2177656	29035	1,60	401,43	1361035	18147
1600×18	894,60	702,3	2799033	34988	1,70	425,18	1646490	20581
1700×19	1003,39	787,7	3544640	41702	1,80	449,00	1969244	23168
1800×20	1118,41	878,0	4430010	49222	1,90	472,89	2331584	25906
1900×21	1239,64	973,1	5471593	57596	2,00	496,83	2735797	28798
2000×22	1367,10	1073,2	6686751	66868	2,10	520,82	3184167	31842
2100×23	1500,77	1178,1	8093763	77083	2,20	544,84	3678983	35038
2200×24	1640,67	1287,9	9711820	88289	2,30	568,90	4222530	38387
2300×25	1786,78	1402,6	11561030	100531	2,40	592,99	4817096	41888
2400×25	1865,32	1464,3	13153425	109612	2,50	593,93	5261370	43845
2500×25	1943,86	1525,9	14885719	119086	2,60	594,80	5725277	45802
2500×26	2020,80	1586,3	15462520	123700	2,60	618,03	5947123	47577

Table 9.3.4 Characteristics of pipe sheet piles, using pipes in compliance with EN and MF130 connectors.

Pipe characteristics					Combination with MF130 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,8	193647	4841	0,93	234,57	208223	5205
800×12	297,07	233,2	230632	5766	0,93	275,83	247991	6200
900×10	279,60	219,5	276876	6153	1,03	235,74	268812	5974
900×12	334,77	262,8	330034	7334	1,03	277,78	320421	7120
1000×10	311,02	244,2	381074	7621	1,13	236,70	337234	6744
1000×12	372,47	292,4	454544	9091	1,13	279,39	402251	8045
1100×13	443,94	348,5	655774	11923	1,23	302,28	533150	9693
1200×13	484,78	380,6	853901	14232	1,33	303,66	642031	10701
1200×14	521,63	409,5	917281	15288	1,33	325,41	689685	11495
1300×15	605,54	475,4	1250028	19231	1,43	348,72	874145	13448
1400×16	695,67	546,1	1665889	23798	1,53	372,17	1088816	15554
1500×17	792,03	621,7	2177656	29035	1,63	395,74	1335985	17813
1600×18	894,60	702,3	2799033	34988	1,73	419,41	1617938	20224
1700×19	1003,39	787,7	3544640	41702	1,83	443,16	1936962	22788
1800×20	1118,41	878,0	4430010	49222	1,93	466,98	2295342	25504
1900×21	1239,64	973,1	5471593	57596	2,03	490,86	2695366	28372
2000×22	1367,10	1073,2	6686751	66868	2,13	514,78	3139320	31393
2100×23	1500,77	1178,1	8093763	77083	2,23	538,75	3629490	34566
2200×24	1640,67	1287,9	9711820	88289	2,33	562,76	4168163	37892
2300×25	1786,78	1402,6	11561030	100531	2,43	586,81	4757626	41371
2400×25	1865,32	1464,3	13153425	109612	2,53	587,98	5198982	43325
2500×25	1943,86	1525,9	14885719	119086	2,63	589,07	5659969	45280
2500×26	2020,80	1586,3	15462520	123700	2,63	612,03	5879285	47034

Table 9.3.5 Characteristics of pipe sheet piles, using pipes in compliance with EN and MF180a connectors.

Pipe characteristics					Combination with MF180a connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,8	193647	4841	0,98	227,56	197599	4940
800×12	297,07	233,2	230632	5766	0,98	266,71	235339	5884
900×10	279,60	219,5	276876	6153	1,08	229,32	256367	5697
900×12	334,77	262,8	330034	7334	1,08	269,42	305587	6791
1000×10	311,02	244,2	381074	7621	1,18	230,79	322944	6458
1000×12	372,47	292,4	454544	9091	1,18	271,67	385207	7704
1100×13	443,94	348,5	655774	11923	1,28	294,27	512323	9315
1200×13	484,78	380,6	853901	14232	1,38	296,18	618769	10313
1200×14	521,63	409,5	917281	15288	1,38	317,14	664696	11078
1300×15	605,54	475,4	1250028	19231	1,48	340,22	844614	12994
1400×16	695,67	546,1	1665889	23798	1,58	363,47	1054360	15062
1500×17	792,03	621,7	2177656	29035	1,68	386,86	1296224	17283
1600×18	894,60	702,3	2799033	34988	1,78	410,36	1572490	19656
1700×19	1003,39	787,7	3544640	41702	1,88	433,96	1885447	22182
1800×20	1118,41	878,0	4430010	49222	1,98	457,64	2237379	24860
1900×21	1239,64	973,1	5471593	57596	2,08	481,39	2630574	27690
2000×22	1367,10	1073,2	6686751	66868	2,18	505,21	3067317	30673
2100×23	1500,77	1178,1	8093763	77083	2,28	529,07	3549896	33808
2200×24	1640,67	1287,9	9711820	88289	2,38	552,98	4080597	37096
2300×25	1786,78	1402,6	11561030	100531	2,48	576,93	4661706	40537
2400×25	1865,32	1464,3	13153425	109612	2,58	578,47	5098227	42485
2500×25	1943,86	1525,9	14885719	119086	2,68	579,89	5554373	44435
2500×26	2020,80	1586,3	15462520	123700	2,68	602,43	5769597	46157

Table 9.3.6 Characteristics of pipe sheet piles, using pipes in compliance with EN and MF180 b connectors.

Pipe characteristics					Combination with MF180b connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,8	193647	4841	0,98	226,70	197599	4940
800×12	297,07	233,2	230632	5766	0,98	265,85	235339	5884
900×10	279,60	219,5	276876	6153	1,08	228,54	256367	5697
900×12	334,77	262,8	330034	7334	1,08	268,63	305587	6791
1000×10	311,02	244,2	381074	7621	1,18	230,07	322944	6458
1000×12	372,47	292,4	454544	9091	1,18	270,95	385207	7704
1100×13	443,94	348,5	655774	11923	1,28	293,61	512323	9315
1200×13	484,78	380,6	853901	14232	1,38	295,57	618769	10313
1200×14	521,63	409,5	917281	15288	1,38	316,53	664696	11078
1300×15	605,54	475,4	1250028	19231	1,48	339,65	844614	12994
1400×16	695,67	546,1	1665889	23798	1,58	362,93	1054360	15062
1500×17	792,03	621,7	2177656	29035	1,68	386,35	1296224	17283
1600×18	894,60	702,3	2799033	34988	1,78	409,88	1572490	19656
1700×19	1003,39	787,7	3544640	41702	1,88	433,51	1885447	22182
1800×20	1118,41	878,0	4430010	49222	1,98	457,21	2237379	24860
1900×21	1239,64	973,1	5471593	57596	2,08	480,99	2630574	27690
2000×22	1367,10	1073,2	6686751	66868	2,18	504,82	3067317	30673
2100×23	1500,77	1178,1	8093763	77083	2,28	528,70	3549896	33808
2200×24	1640,67	1287,9	9711820	88289	2,38	552,63	4080597	37096
2300×25	1786,78	1402,6	11561030	100531	2,48	576,59	4661706	40537
2400×25	1865,32	1464,3	13153425	109612	2,58	578,15	5098227	42485
2500×25	1943,86	1525,9	14885719	119086	2,68	579,58	5554373	44435
2500×26	2020,80	1586,3	15462520	123700	2,68	602,11	5769597	46157

Table 9.3.7 Characteristics of pipe sheet piles, using pipes in compliance with EN and MF230 connectors.

Pipe characteristics					Combination with MF230 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
800×10	248,19	194,8	193647	4841	1,03	220,41	188007	4700
800×12	297,07	233,2	230632	5766	1,03	257,66	223915	5598
900×10	279,60	219,5	276876	6153	1,13	222,73	245023	5445
900×12	334,77	262,8	330034	7334	1,13	261,05	292065	6490
1000×10	311,02	244,2	381074	7621	1,23	224,67	309816	6196
1000×12	372,47	292,4	454544	9091	1,23	263,89	369548	7391
1100×13	443,94	348,5	655774	11923	1,33	286,23	493063	8965
1200×13	484,78	380,6	853901	14232	1,43	288,63	597134	9952
1200×14	521,63	409,5	917281	15288	1,43	308,86	641455	10691
1300×15	605,54	475,4	1250028	19231	1,53	331,73	817012	12569
1400×16	695,67	546,1	1665889	23798	1,63	354,78	1022018	14600
1500×17	792,03	621,7	2177656	29035	1,73	378,00	1258761	16783
1600×18	894,60	702,3	2799033	34988	1,83	401,34	1529526	19119
1700×19	1003,39	787,7	3544640	41702	1,93	424,79	1836601	21607
1800×20	1118,41	878,0	4430010	49222	2,03	448,35	2182271	24247
1900×21	1239,64	973,1	5471593	57596	2,13	471,98	2568823	27040
2000×22	1367,10	1073,2	6686751	66868	2,23	495,68	2998543	29986
2100×23	1500,77	1178,1	8093763	77083	2,33	519,44	3473718	33083
2200×24	1640,67	1287,9	9711820	88289	2,43	543,26	3996634	36333
2300×25	1786,78	1402,6	11561030	100531	2,53	567,12	4569577	39736
2400×25	1865,32	1464,3	13153425	109612	2,63	569,00	5001302	41678
2500×25	1943,86	1525,9	14885719	119086	2,73	570,74	5452644	43621
2500×26	2020,80	1586,3	15462520	123700	2,73	592,87	5663927	45311

9.4 Attachment 4. Characteristics of pipe sheet piles made of pipes in compliance with EN when using DTH method.

Table 9.4.1 Data for the applying MF64 connector.

Pipe characteristics					Combination with MF64 connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
400×12	146,27	114,82	27552	1378	0,46	284,46	59379	2969
400×13	158,05	124,07	29623	1481	0,46	304,39	63843	3191
400×14	169,77	133,27	31661	1583	0,46	324,22	68235	3411
500×14	213,75	167,80	63162	2526	0,56	327,96	111989	4478
600×14	257,74	202,32	110695	3690	0,66	330,56	166709	5557
700×14	301,72	236,85	177558	5073	0,76	332,49	232406	6640
700×15	322,80	253,40	189422	5412	0,76	354,15	247935	7083
700×16	343,82	269,90	201180	5748	0,76	375,74	263325	7523
700×17	364,77	286,34	212833	6081	0,76	397,26	278577	7959
700×18	385,66	302,74	224382	6411	0,76	418,73	293694	8391
800×17	418,18	328,27	320626	8016	0,86	399,81	371095	9277
800×19	466,18	365,95	355651	8891	0,86	443,42	411633	10290
900×16	444,35	348,81	434189	9649	0,96	379,65	450404	10009
900×17	471,58	370,19	459782	10217	0,96	401,82	476952	10598
900×18	498,76	391,53	485198	10782	0,96	423,96	503317	11184
1000×18	555,31	435,92	669596	13392	1,06	425,84	629320	12586
1100×18	611,86	480,31	895642	16284	1,16	427,39	769452	13989
1100×19	645,25	506,52	942811	17142	1,16	449,90	809975	14726
1100×20	678,58	532,69	989715	17995	1,16	472,39	850271	15459
1200×18	668,41	524,70	1167577	19460	1,26	428,69	923716	15395
1200×19	704,94	553,38	1229350	20489	1,26	451,38	972587	16209
1200×20	741,42	582,01	1290805	21513	1,26	474,03	1021206	17019
1300×18	724,95	569,09	1489643	22918	1,36	429,81	1092114	16802
1300×19	764,63	600,24	1568760	24135	1,36	452,65	1150117	17694
1300×21	843,80	662,38	1725869	26552	1,36	498,20	1265300	19466
1300×22	883,29	693,38	1803864	27752	1,36	520,93	1322481	20346
1400×18	781,50	613,48	1866080	26658	1,46	430,77	1274645	18209
1400×19	824,32	647,09	1965517	28079	1,46	453,73	1342566	19179
1400×20	867,08	680,66	2064516	29493	1,46	476,66	1410189	20145
1400×21	909,77	714,17	2163081	30901	1,46	499,55	1477514	21107
1400×22	952,41	747,64	2261210	32303	1,46	522,41	1544542	22064
1500×20	929,91	729,98	2546562	33954	1,56	477,72	1628237	21709
1500×21	975,75	765,96	2668525	35580	1,56	500,72	1706218	22749
1500×22	1021,52	801,89	2789986	37200	1,56	523,70	1783879	23785

Table 9.4.2 Data for the applying MF64-IC connector

Pipe characteristics					Combination with MF64-IC connector			
Pipe	**Cross-sectional area**	**Weight, m/kg**	**Moment of inertia**	**Section modulus**	**Combination width**	**Weight, 1m^2,kg**	**Moment of inertia**	**Section modulus**
D × t	**A,cm^2**	**G**	**I, cm^4**	**W, cm^3**	**b_{sys},m**	**G97%**	**I_{sys}, cm^4**	**W_{sys},cm^3**
400×12	146,27	114,82	27552	1378	0,46	282,93	59379	2969
400×13	158,05	124,07	29623	1481	0,46	302,87	63843	3191
400×14	169,77	133,27	31661	1583	0,46	322,70	68235	3411
500×14	213,75	167,80	63162	2526	0,56	326,70	111989	4478
600×14	257,74	202,32	110695	3690	0,66	329,49	166709	5557
700×14	301,72	236,85	177558	5073	0,76	331,56	232406	6640
700×15	322,80	253,40	189422	5412	0,76	353,22	247935	7083
700×16	343,82	269,90	201180	5748	0,76	374,82	263325	7523
700×17	364,77	286,34	212833	6081	0,76	396,34	278577	7959
700×18	385,66	302,74	224382	6411	0,76	417,80	293694	8391
800×17	418,18	328,27	320626	8016	0,86	398,99	371095	9277
800×19	466,18	365,95	355651	8891	0,86	442,61	411633	10290
900×16	444,35	348,81	434189	9649	0,96	378,91	450404	10009
900×17	471,58	370,19	459782	10217	0,96	401,09	476952	10598
900×18	498,76	391,53	485198	10782	0,96	423,23	503317	11184
1000×18	555,31	435,92	669596	13392	1,06	425,17	629320	12586
1100×18	611,86	480,31	895642	16284	1,16	426,78	769452	13989
1100×19	645,25	506,52	942811	17142	1,16	449,30	809975	14726
1100×20	678,58	532,69	989715	17995	1,16	471,78	850271	15459
1200×18	668,41	524,70	1167577	19460	1,26	428,13	923716	15395
1200×19	704,94	553,38	1229350	20489	1,26	450,82	972587	16209
1200×20	741,42	582,01	1290805	21513	1,26	473,47	1021206	17019
1300×18	724,95	569,09	1489643	22918	1,36	429,29	1092114	16802
1300×19	764,63	600,24	1568760	24135	1,36	452,13	1150117	17694
1300×21	843,80	662,38	1725869	26552	1,36	497,68	1265300	19466
1300×22	883,29	693,38	1803864	27752	1,36	520,41	1322481	20346
1400×18	781,50	613,48	1866080	26658	1,46	430,29	1274645	18209
1400×19	824,32	647,09	1965517	28079	1,46	453,25	1342566	19179
1400×20	867,08	680,66	2064516	29493	1,46	476,18	1410189	20145
1400×21	909,77	714,17	2163081	30901	1,46	499,06	1477514	21107
1400×22	952,41	747,64	2261210	32303	1,46	521,93	1544542	22064
1500×20	929,91	729,98	2546562	33954	1,56	477,26	1628237	21709
1500×21	975,75	765,96	2668525	35580	1,56	500,27	1706218	22749
1500×22	1021,52	801,89	2789986	37200	1,56	523,24	1783879	23785

9.5 Attachment 5. Characteristics of H-beam sheet piles made of hot rolled H-beams.

Table 9.5.1 a) H-beams in compliance with EN10034 з applying LPB180-12 connectors, two-flange connected(Fig. 9.5.1.1)

Characteristics of Hot rolled H-beams																		Characteristics of welded sections			**Combination**			
Combination name	Weight	Cross-sectional height	Flange thickness	Flange thickness	Web thickness	Conjugation radius	Cross-sectional area	Surface area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	Shear area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
	G, kg/m	h, mm	b, mm	t_w,mm	t_f, mm	r, mm	A, cm^2	m^2/m	I_y, cm^4	W_y cm^3	$W_{pl.y}$, cm^3	i_y ,cm	A_{vz} , cm^2	I_z, cm^4	W_z, cm^3	$W_{pl.z}$, cm3	i_z, cm	cm	I_y, cm^4	W_y, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-UB 610 x 305 x 179-4LPB180-12c	179	620,2	307,1	14,1	23,6	17	228	2,412	153024	4935	5547	25,9	94,2	11408	743	1144	7,07	31,01	218830	7057	0,49	482,98	449250	14487
БДП-UB 610 x 305 x 238-4LPB180-12c	238	635,8	311,4	18,4	31,4	17	303	2,452	209471	6589	7486	26,28	124	15837	1017	1574	7,23	31,79	277007	8714	0,49	598,82	563710	17732
БДП-UB 686 x 254 x 152-4LPB180-12c	152	687,5	254,5	13,2	21	15	194	2,341	150355	4374	5000	27,83	96,3	5784	455	710	5,46	34,38	232469	6763	0,43	479,31	535027	15564
БДП-UB 686 x 254 x 170-4LPB180-12c	170	692,9	255,8	14,5	23,7	15	217	2,354	170326	4916	5631	28,03	106	6630	518	811	5,53	34,65	253106	7306	0,44	519,18	580786	16764
БДП-UB 762 x 267 x 173-4LPB180-12c	173	762,2	266,7	14,3	21,6	17	220	2,534	205282	5387	6198	30,52	115	6850	514	807	5,58	38,11	306656	8047	0,45	513,23	686491	18013
БДП-UB 762 x 267 x 197-4LPB180-12c	197	769,8	268	15,6	25,4	17	251	2,552	239957	6234	7167	30,94	127	8175	610	959	5,71	38,49	342373	8895	0,45	565,31	764226	19855
БДП-UB 838 x 292 x 194-4LPB180-12c	194	840,7	292,4	14,7	21,7	18	247	2,791	279175	6641	7640	33,63	131	9066	620	974	6,06	42,04	403134	9590	0,47	529,76	853374	20302
БДП-UB 838 x 292 x 226-4LPB180-12c	227	850,9	293,8	16,1	26,8	18	289	2,814	339704	7985	9155	34,31	145	11360	773	1212	6,27	42,55	465211	10935	0,47	597,85	981872	23078
БДП-UB 914 x 305 x 201-4LPB180-12c	201	903	303,3	15,1	20,2	19	256	2,956	325254	7204	8351	35,65	144	9423	621	982	6,07	45,15	469268	10394	0,48	532,30	970967	21505
БДП-UB 914 x 305 x 224-4LPB180-12c	224	910,4	304,1	15,9	23,9	19	286	2,973	376413	8269	9535	36,3	153	11236	739	1163	6,27	45,52	521637	11460	0,48	578,93	1077539	23672
БДП-UB 914 x 305 x 238-4LPB180-12c	238	915	305	16,5	25,9	19	304	2,984	406472	8885	10231	36,59	160	12285	806	1267	6,36	45,75	552548	12078	0,49	606,72	1139275	24902
БДП-UB 914 x 305 x 253-4LPB180-12c	253	918,4	305,5	17,3	27,9	19	323	2,991	436304	9501	10942	36,76	168	13301	871	1371	6,42	45,92	582840	12693	0,49	636,99	1200495	26143
БДП-UB 914 x 305 x 271-4LPB180-12c	271	923	307	18,4	30	19	346	3,004	471633	10220	11784	36,91	179	14518	946	1491	6,48	46,15	618993	13413	0,49	671,99	1271033	27541
БДП-UB 914 x 305 x 289-4LPB180-12c	289	926,6	307,7	19,5	32	19	368	3,012	504187	10883	12570	37	190	15597	1014	1601	6,51	46,33	652075	14075	0,49	707,94	1337042	28859
БДП-UB 914 x 305 x 313-4LPB180-12c	313	932	309	21,1	34,5	19	398	3,025	548297	11766	13630	37,1	206	17039	1103	1748	6,54	46,60	697145	14960	0,49	755,13	1425655	30593
БДП-UB 914 x 305 x 345-4LPB180-12c	345	943	308	22,1	39,9	19	440	3,041	625645	13269	15349	37,72	218	19515	1267	2003	6,66	47,15	776356	16466	0,49	822,25	1590893	33741
БДП-UB 914 x 419 x 343-4LPB180-12c	343	911,8	418,5	19,4	32	24	437	3,417	625779	13726	15477	37,83	191	39156	1871	2890	9,46	45,59	768817	16864	0,60	667,10	1284572	28177
БДП-UB 914 x 419 x 388-4LPB180-12c	388	921	420,5	21,4	36,6	24	494	3,44	719635	15627	17665	38,16	212	45438	2161	3341	9,59	46,05	864172	18766	0,60	739,82	1439087	31251
БДП-UB 1016 x 305 x 222-4LPB180-12c	222	970	300	16	21,1	30	283	3,056	407667	8405	9803	37,97	172	9546	636	1020	5,81	48,50	574046	11836	0,48	579,71	1195928	24658
БДП-UB 1016 x 305 x 249-4LPB180-12c	249	980	300	16,5	26	30	317	3,075	481079	9818	11347	38,97	181	11754	784	1245	6,09	49,00	649250	13250	0,48	635,96	1352604	27604
БДП-UB 1016 x 305 x 272-4LPB180-12c	272	990	300	16,5	31	30	347	3,095	553846	11189	12824	39,96	185	14004	934	1470	6,35	49,50	723784	14622	0,48	683,88	1507883	30462
БДП-UB 1016 x 305 x 314-4LPB180-12c	314	1000	300	19,1	35,9	30	400	3,11	644211	12884	14851	40,11	213	16232	1082	1713	6,37	50,00	815961	16319	0,48	771,38	1699918	33998
БДП-UB 1016 x 305 x 350-4LPB180-12c	350	1008	302	21,1	40	30	445	3,13	722965	14345	16589	40,3	236	18460	1223	1941	6,44	50,40	896106	17780	0,48	842,86	1859142	36888
БДП-UB 1016 x 305 x 393-4LPB180-12c	393	1016	303	24,4	43,9	30	500	3,144	807688	15899	18539	40,18	271	20496	1353	2168	6,4	50,80	982299	19337	0,48	930,14	2033745	40034
БДП-UB 1016 x 305 x 415-4LPB180-12c	415	1020	304	26	46	30	529	3,152	853121	16728	19571	40,17	289	21707	1428	2298	6,41	51,00	1028415	20165	0,48	973,68	2124824	41663
БДП-UB 1016 x 305 x 438-4LPB180-12c	438	1026	305	26,9	49	30	556	3,167	909177	17723	20746	40,43	300	23355	1531	2463	6,48	51,30	1085552	21161	0,49	1019,09	2238251	43631
БДП-UB 1016 x 305 x 487* -4LPB180-12c	487	1036,3	308,5	30	54,1	30	620	3,195	1021884	19722	23206	40,6	335	26721	1732	2800	6,57	51,82	1200141	23162	0,49	1112,10	2456787	47415
БДП-UB 1016 x 305 x 494 -4LPB180-12c	494	1036	309	31	54	30	629	3,194	1027959	19845	23413	40,42	345	26824	1736	2818	6,53	51,80	1206143	23285	0,49	1125,28	2466550	47617

Table 9.5.1 b) H-beams in compliance with EN10034 з applying LPB180-12 connectors, one-flange connected(Fig. 9.5.1.2)

Characteristics of Hot rolled H-beams																		Characteristics of welded sections			**Combination**			
Combination name	Weight	Cross-sectional height	Flange thickness	Flange thickness	Web thickness	Conjugation radius	Cross-sectional area	Surface area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	Shear area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
	G, kg/m	h, mm	b, mm	t_w,mm	t_f, mm	r, mm	A, cm^2	m^2/m	I_y, cm^4	W_y cm^3	$W_{pl,y}$, cm^3	i_y ,cm	A_{vz} , cm^2	I_z, cm^4	W_z, cm^3	$W_{pl,z}$, cm3	i_z, cm	cm	I_y, cm^4	Wy, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-UB 610 x 305 x 179-2LPB180-12c	179	620,2	307,1	14,1	23,6	17	228	2,412	153024	4935	5547	25,9	94,2	11408	743	1144	7,07	27	181347	5157	0,49	425,23	372299	10587
БДП-UB 610 x 305 x 238-2LPB180-12c	238	635,8	311,4	18,4	31,4	17	303	2,452	209471	6589	7486	26,28	124	15837	1017	1574	7,23	29	239573	6830	0,49	541,58	487531	13900
БДП-UB 686 x 254 x 152-2LPB180-12c	152	687,5	254,5	13,2	21	15	194	2,341	150355	4374	5000	27,83	96,3	5784	455	710	5,46	29	184849	4655	0,43	414,57	425430	10715
БДП-UB 686 x 254 x 170-2LPB180-12c	170	692,9	255,8	14,5	23,7	15	217	2,354	170326	4916	5631	28,03	106	6630	518	811	5,53	30	205699	5206	0,44	454,64	472004	11946
БДП-UB 762 x 267 x 173-2LPB180-12c	173	762,2	266,7	14,3	21,6	17	220	2,534	205282	5387	6198	30,52	115	6850	514	807	5,58	33	248686	5726	0,45	450,26	556717	12818
БДП-UB 762 x 267 x 197-2LPB180-12c	197	769,8	268	15,6	25,4	17	251	2,552	239957	6234	7167	30,94	127	8175	610	959	5,71	34	284599	6578	0,45	502,52	635266	14683
БДП-UB 838 x 292 x 194-2LPB180-12c	194	840,7	292,4	14,7	21,7	18	247	2,791	279175	6641	7640	33,63	131	9066	620	974	6,06	37	333095	7033	0,47	470,22	705111	14887
БДП-UB 838 x 292 x 226-2LPB180-12c	227	850,9	293,8	16,1	26,8	18	289	2,814	339704	7985	9155	34,31	145	11360	773	1212	6,27	38	395348	8373	0,47	538,48	834420	17673
БДП-UB 914 x 305 x 201-2LPB180-12c	201	903	303,3	15,1	20,2	19	256	2,956	325254	7204	8351	35,65	144	9423	621	982	6,07	40	388184	7654	0,48	474,09	803195	15837
БДП-UB 914 x 305 x 224-2LPB180-12c	224	910,4	304,1	15,9	23,9	19	286	2,973	376413	8269	9535	36,3	153	11236	739	1163	6,27	40	440722	8712	0,48	520,82	910394	17995
БДП-UB 914 x 305 x 238-2LPB180-12c	238	915	305	16,5	25,9	19	304	2,984	406472	8885	10231	36,59	160	12285	806	1267	6,36	41	471599	9326	0,49	548,72	972370	19229
БДП-UB 914 x 305 x 253-2LPB180-12c	253	918,4	305,5	17,3	27,9	19	323	2,991	436304	9501	10942	36,76	168	13301	871	1371	6,42	41	502055	9944	0,49	579,05	1034100	20481
БДП-UB 914 x 305 x 271-2LPB180-12c	271	923	307	18,4	30	19	346	3,004	471633	10220	11784	36,91	179	14518	946	1491	6,48	42	538208	10667	0,49	614,23	1105150	21903
БДП-UB 914 x 305 x 289-2LPB180-12c	289	926,6	307,7	19,5	32	19	368	3,012	504187	10883	12570	37	190	15597	1014	1601	6,51	42	571388	11335	0,49	650,26	1171597	23241
БДП-UB 914 x 305 x 313-2LPB180-12c	313	932	309	21,1	34,5	19	398	3,025	548297	11766	13630	37,1	206	17039	1103	1748	6,54	43	616402	12227	0,49	697,61	1260537	25005
БДП-UB 914 x 305 x 345-2LPB180-12c	345	943	308	22,1	39,9	19	440	3,041	625645	13269	15349	37,72	218	19515	1267	2003	6,66	44	695166	13726	0,49	764,61	1424520	28126
БДП-UB 914 x 419 x 343-2LPB180-12c	343	911,8	418,5	19,4	32	24	437	3,417	625779	13726	15477	37,83	191	39156	1871	2890	9,46	42	691725	14111	0,60	620,10	1155765	23578
БДП-UB 914 x 419 x 388-2LPB180-12c	388	921	420,5	21,4	36,6	24	494	3,44	719635	15627	17665	38,16	212	45438	2161	3341	9,59	43	786877	16017	0,60	692,97	1310370	26673
БДП-UB 1016 x 305 x 222-2LPB180-12c	222	970	300	16	21,1	30	283	3,056	407667	8405	9803	37,97	172	9546	636	1020	5,81	43	481254	8916	0,48	521,10	1002613	18574
БДП-UB 1016 x 305 x 249-2LPB180-12c	249	980	300	16,5	26	30	317	3,075	481079	9818	11347	38,97	181	11754	784	1245	6,09	44	556391	10308	0,48	577,35	1159149	21474
БДП-UB 1016 x 305 x 272-2LPB180-12c	272	990	300	16,5	31	30	347	3,095	553846	11189	12824	39,96	185	14004	934	1470	6,35	45	630642	11654	0,48	625,27	1313838	24279
БДП-UB 1016 x 305 x 314-2LPB180-12c	314	1000	300	19,1	35,9	30	400	3,11	644211	12884	14851	40,11	213	16232	1082	1713	6,37	46	722828	13367	0,48	712,77	1505891	27848
БДП-UB 1016 x 305 x 350-2LPB180-12c	350	1008	302	21,1	40	30	445	3,13	722965	14345	16589	40,3	236	18460	1223	1941	6,44	47	802902	14838	0,48	784,50	1665772	30785
БДП-UB 1016 x 305 x 393-2LPB180-12c	393	1016	303	24,4	43,9	30	500	3,144	807688	15899	18539	40,18	271	20496	1353	2168	6,4	47	888989	16419	0,48	871,90	1840556	33994
БДП-UB 1016 x 305 x 415-2LPB180-12c	415	1020	304	26	46	30	529	3,152	853121	16728	19571	40,17	289	21707	1428	2298	6,41	48	935049	17259	0,48	915,56	1931919	35658
БДП-UB 1016 x 305 x 438-2LPB180-12c	438	1026	305	26,9	49	30	556	3,167	909177	17723	20746	40,43	300	23355	1531	2463	6,48	48	991872	18252	0,49	961,09	2045097	37633
БДП-UB 1016 x 305 x 487* -2LPB180-12c	487	1036,3	308,5	30	54,1	30	620	3,195	1021884	19722	23206	40,6	335	26721	1732	2800	6,57	49	1106002	20265	0,49	1054,51	2264078	41484
БДП-UB 1016 x 305 x 494 -2LPB180-12c	494	1036	309	31	54	30	629	3,194	1027959	19845	23413	40,42	345	26824	1736	2818	6,53	49	1112110	20397	0,489	1067,75	2274254	41711

Note. Symbols for beams used in the Table 9.5.1:

БДП-UB 610 × 305 × 179-2LPB180-12c

Where: БДП – is a beam type – the H-beam, hot rolled; UB 610 × 305 × 179 – is a beam grade according to a standard document. 610 –beam height in mm; 305-beam width in mm; 179 – weight of a linear meter in kg. 2 or 4 – the number of sets of connectors per one beam, installed in one or two of its decks accordingly. LPB180-12– the connector type used.

With this 180 – distance between connected beams, c - type of welding a beam to a connector (butt welding).

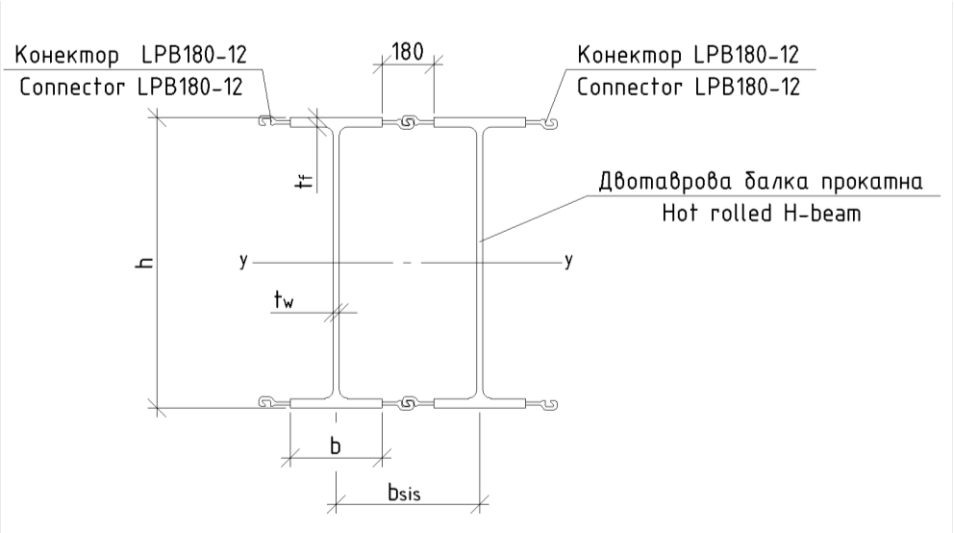


Fig.9.5.1.1 Cross-section of БДП beam using hot rolled steel according to EN10034 and 4 connectors LPB180-12

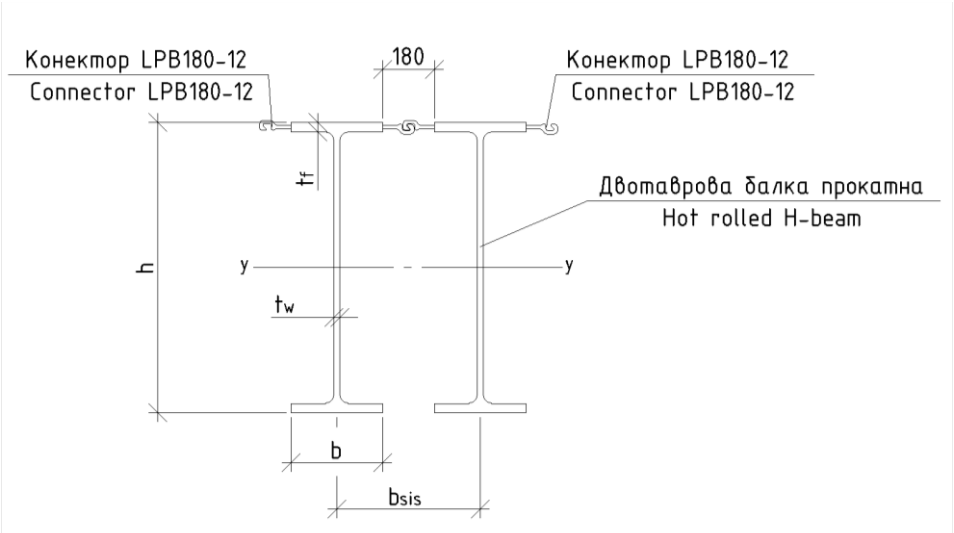


Fig.9.5.1.2 Cross-section of БДП beam using hot rolled steel according to EN10034 and 2 connectors LPB180-12

Table 9.5.2 a) H-beams in compliance with EN10034 applying LPB100-10 connectors, two-flange connected(Fig. 9.5.2.1)

Characteristics of Hot rolled H-beams																		Characteristics of welded sections			**Combination**			
Combination name	Weight	Cross-sectional height	Flange thickness	Flange thickness	Web thickness	Conjugation radius	Cross-sectional area	Surface area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	Shear area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
	G, kg/m	h, mm	b, mm	t_w,mm	t_f, mm	r, mm	A, cm^2	m^2/m	I_y, cm^4	W_y cm^3	$W_{pl,y}$, cm^3	i_y ,cm	A_{vz} , cm^2	I_z, cm^4	W_z, cm^3	$W_{pl,z}$, cm3	i_z, cm	cm	I_y, cm^4	Wy, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-UB 610 x 305 x 179-4LPB100-10c	179	620,2	307,1	14,1	23,6	17	228	2,412	153024	4935	5547	25,9	94,2	11408	743	1144	7,07	31,01	197573	6371	0,41	533,67	485318	15650
БДП-UB 610 x 305 x 238-4LPB100-10c	238	635,8	311,4	18,4	31,4	17	303	2,452	209471	6589	7486	26,28	124	15837	1017	1574	7,23	31,79	255191	8027	0,41	671,50	620300	19512
БДП-UB 686 x 254 x 152-4LPB100-10c	152	687,5	254,5	13,2	21	15	194	2,341	150355	4374	5000	27,83	96,3	5784	455	710	5,46	34,38	205942	5991	0,35	536,69	580938	16900
БДП-UB 686 x 254 x 170-4LPB100-10c	170	692,9	255,8	14,5	23,7	15	217	2,354	170326	4916	5631	28,03	106	6630	518	811	5,53	34,65	226364	6534	0,36	585,32	636212	18364
БДП-UB 762 x 267 x 173-4LPB100-10c	173	762,2	266,7	14,3	21,6	17	220	2,534	205282	5387	6198	30,52	115	6850	514	807	5,58	38,11	273905	7187	0,37	576,10	746946	19600
БДП-UB 762 x 267 x 197-4LPB100-10c	197	769,8	268	15,6	25,4	17	251	2,552	239957	6234	7167	30,94	127	8175	610	959	5,71	38,49	309285	8035	0,37	639,28	840450	21836
БДП-UB 838 x 292 x 194-4LPB100-10c	194	840,7	292,4	14,7	21,7	18	247	2,791	279175	6641	7640	33,63	131	9066	620	974	6,06	42,04	363085	8638	0,39	591,89	925292	22012
БДП-UB 838 x 292 x 226-4LPB100-10c	227	850,9	293,8	16,1	26,8	18	289	2,814	339704	7985	9155	34,31	145	11360	773	1212	6,27	42,55	424661	9981	0,39	673,58	1078368	25347
БДП-UB 914 x 305 x 201-4LPB100-10c	201	903	303,3	15,1	20,2	19	256	2,956	325254	7204	8351	35,65	144	9423	621	982	6,07	45,15	422738	9363	0,40	593,25	1048197	23216
БДП-UB 914 x 305 x 224-4LPB100-10c	224	910,4	304,1	15,9	23,9	19	286	2,973	376413	8269	9535	36,3	153	11236	739	1163	6,27	45,52	474715	10429	0,40	648,99	1174747	25807
БДП-UB 914 x 305 x 238-4LPB100-10c	238	915	305	16,5	25,9	19	304	2,984	406472	8885	10231	36,59	160	12285	806	1267	6,36	45,75	505352	11046	0,41	682,12	1247782	27274
БДП-UB 914 x 305 x 253-4LPB100-10c	253	918,4	305,5	17,3	27,9	19	323	2,991	436304	9501	10942	36,76	168	13301	871	1371	6,42	45,92	535495	11661	0,41	718,27	1320580	28758
БДП-UB 914 x 305 x 271-4LPB100-10c	271	923	307	18,4	30	19	346	3,004	471633	10220	11784	36,91	179	14518	946	1491	6,48	46,15	571381	12381	0,41	759,84	1403886	30420
БДП-UB 914 x 305 x 289-4LPB100-10c	289	926,6	307,7	19,5	32	19	368	3,012	504187	10883	12570	37	190	15597	1014	1601	6,51	46,33	604293	13043	0,41	802,69	1482200	31992
БДП-UB 914 x 305 x 313-4LPB100-10c	313	932	309	21,1	34,5	19	398	3,025	548297	11766	13630	37,1	206	17039	1103	1748	6,54	46,60	649053	13928	0,41	858,82	1586926	34054
БДП-UB 914 x 305 x 345-4LPB100-10c	345	943	308	22,1	39,9	19	440	3,041	625645	13269	15349	37,72	218	19515	1267	2003	6,66	47,15	727661	15433	0,41	939,35	1783484	37826
БДП-UB 914 x 419 x 343-4LPB100-10c	343	911,8	418,5	19,4	32	24	437	3,417	625779	13726	15477	37,83	191	39156	1871	2890	9,46	45,59	722602	15850	0,52	735,31	1393639	30569
БДП-UB 914 x 419 x 388-4LPB100-10c	388	921	420,5	21,4	36,6	24	494	3,44	719635	15627	17665	38,16	212	45438	2161	3341	9,59	46,05	817472	17752	0,52	818,94	1570552	34105
БДП-UB 1016 x 305 x 222-4LPB100-10c	222	970	300	16	21,1	30	283	3,056	407667	8405	9803	37,97	172	9546	636	1020	5,81	48,50	520288	10728	0,40	650,64	1300720	26819
БДП-UB 1016 x 305 x 249-4LPB100-10c	249	980	300	16,5	26	30	317	3,075	481079	9818	11347	38,97	181	11754	784	1245	6,09	49,00	594913	12141	0,40	718,14	1487283	30353
БДП-UB 1016 x 305 x 272-4LPB100-10c	272	990	300	16,5	31	30	347	3,095	553846	11189	12824	39,96	185	14004	934	1470	6,35	49,50	668876	13513	0,40	775,64	1672190	33782
БДП-UB 1016 x 305 x 314-4LPB100-10c	314	1000	300	19,1	35,9	30	400	3,11	644211	12884	14851	40,11	213	16232	1082	1713	6,37	50,00	760467	15209	0,40	880,64	1901168	38023
БДП-UB 1016 x 305 x 350-4LPB100-10c	350	1008	302	21,1	40	30	445	3,13	722965	14345	16589	40,3	236	18460	1223	1941	6,44	50,40	840163	16670	0,40	965,81	2089959	41467
БДП-UB 1016 x 305 x 393-4LPB100-10c	393	1016	303	24,4	43,9	30	500	3,144	807688	15899	18539	40,18	271	20496	1353	2168	6,4	50,80	925881	18226	0,40	1070,12	2297471	45226
БДП-UB 1016 x 305 x 415-4LPB100-10c	415	1020	304	26	46	30	529	3,152	853121	16728	19571	40,17	289	21707	1428	2298	6,41	51,00	971776	19054	0,40	1121,92	2405387	47164
БДП-UB 1016 x 305 x 438-4LPB100-10c	438	1026	305	26,9	49	30	556	3,167	909177	17723	20746	40,43	300	23355	1531	2463	6,48	51,30	1028564	20050	0,41	1175,94	2539664	49506
БДП-UB 1016 x 305 x 487* -4LPB100-10c	487	1036,3	308,5	30	54,1	30	620	3,195	1021884	19722	23206	40,6	335	26721	1732	2800	6,57	51,82	1142545	22050	0,41	1285,82	2796927	53979
БДП-UB 1016 x 305 x 494 -4LPB100-10c	494	1036	309	31	54	30	629	3,194	1027959	19845	23413	40,42	345	26824	1736	2818	6,53	51,80	1148571	22173	0,41	1301,36	2808241	54213

Table 9.5.2 b H-beams in compliance with EN10034 applying LPB100-10 connectors, one-flange connected(Fig. 9.5.2.2)

Characteristics of Hot rolled H-beams																		Characteristics of welded sections			**Combination**			
Combination name	Weight	Cross-sectional height	Flange thickness	Flange thickness	Web thickness	Conjugation radius	Cross-sectional area	Surface area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	Shear area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
	G, kg/m	h, mm	b, mm	t_w,mm	t_f, mm	r, mm	A, cm^2	m^2/m	I_y, cm^4	W_y cm^3	$W_{pl,y}$, cm^3	i_y ,cm	A_{vz} , cm^2	I_z, cm^4	W_z, cm^3	$W_{pl,z}$, cm3	i_z, cm	cm	I_y, cm^4	Wy, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-UB 610 x 305 x 179-2LPB100-10c	179	620,2	307,1	14,1	23,6	17	228	2,412	153024	4935	5547	25,9	94,2	11408	743	1144	7,07	28	173101	5098	0,41	486,68	425206	12522
БДП-UB 610 x 305 x 238-2LPB100-10c	238	635,8	311,4	18,4	31,4	17	303	2,452	209471	6589	7486	26,28	124	15837	1017	1574	7,23	29	230590	6763	0,41	625,01	560502	16440
БДП-UB 686 x 254 x 152-2LPB100-10c	152	687,5	254,5	13,2	21	15	194	2,341	150355	4374	5000	27,83	96,3	5784	455	710	5,46	31	174978	4583	0,35	482,73	493592	12928
БДП-UB 686 x 254 x 170-2LPB100-10c	170	692,9	255,8	14,5	23,7	15	217	2,354	170326	4916	5631	28,03	106	6630	518	811	5,53	31	195453	5130	0,36	531,56	549333	14417
БДП-UB 762 x 267 x 173-2LPB100-10c	173	762,2	266,7	14,3	21,6	17	220	2,534	205282	5387	6198	30,52	115	6850	514	807	5,58	34	236094	5636	0,37	523,94	643835	15370
БДП-UB 762 x 267 x 197-2LPB100-10c	197	769,8	268	15,6	25,4	17	251	2,552	239957	6234	7167	30,94	127	8175	610	959	5,71	35	271483	6485	0,37	587,31	737726	17623
БДП-UB 838 x 292 x 194-2LPB100-10c	194	840,7	292,4	14,7	21,7	18	247	2,791	279175	6641	7640	33,63	131	9066	620	974	6,06	38	317275	6928	0,39	543,14	808551	17654
БДП-UB 838 x 292 x 226-2LPB100-10c	227	850,9	293,8	16,1	26,8	18	289	2,814	339704	7985	9155	34,31	145	11360	773	1212	6,27	39	378802	8266	0,39	625,01	961915	20991
БДП-UB 914 x 305 x 201-2LPB100-10c	201	903	303,3	15,1	20,2	19	256	2,956	325254	7204	8351	35,65	144	9423	621	982	6,07	41	369661	7532	0,40	545,82	916591	18676
БДП-UB 914 x 305 x 224-2LPB100-10c	224	910,4	304,1	15,9	23,9	19	286	2,973	376413	8269	9535	36,3	153	11236	739	1163	6,27	42	421614	8590	0,40	601,65	1043342	21256
БДП-UB 914 x 305 x 238-2LPB100-10c	238	915	305	16,5	25,9	19	304	2,984	406472	8885	10231	36,59	160	12285	806	1267	6,36	42	452156	9204	0,41	634,88	1116435	22725
БДП-UB 914 x 305 x 253-2LPB100-10c	253	918,4	305,5	17,3	27,9	19	323	2,991	436304	9501	10942	36,76	168	13301	871	1371	6,42	43	482338	9820	0,41	671,09	1189489	24216
БДП-UB 914 x 305 x 271-2LPB100-10c	271	923	307	18,4	30	19	346	3,004	471633	10220	11784	36,91	179	14518	946	1491	6,48	43	518148	10540	0,41	712,85	1273090	25897
БДП-UB 914 x 305 x 289-2LPB100-10c	289	926,6	307,7	19,5	32	19	368	3,012	504187	10883	12570	37	190	15597	1014	1601	6,51	43	551057	11206	0,41	755,77	1351624	27485
БДП-UB 914 x 305 x 313-2LPB100-10c	313	932	309	21,1	34,5	19	398	3,025	548297	11766	13630	37,1	206	17039	1103	1748	6,54	44	595698	12095	0,41	812,05	1456475	29572
БДП-UB 914 x 305 x 345-2LPB100-10c	345	943	308	22,1	39,9	19	440	3,041	625645	13269	15349	37,72	218	19515	1267	2003	6,66	45	673912	13593	0,41	892,47	1651744	33316
БДП-UB 914 x 419 x 343-2LPB100-10c	343	911,8	418,5	19,4	32	24	437	3,417	625779	13726	15477	37,83	191	39156	1871	2890	9,46	43	671572	14000	0,52	698,42	1295220	27000
БДП-UB 914 x 419 x 388-2LPB100-10c	388	921	420,5	21,4	36,6	24	494	3,44	719635	15627	17665	38,16	212	45438	2161	3341	9,59	44	766198	15903	0,52	782,19	1472043	30553
БДП-UB 1016 x 305 x 222-2LPB100-10c	222	970	300	16	21,1	30	283	3,056	407667	8405	9803	37,97	172	9546	636	1020	5,81	45	459408	8775	0,40	602,82	1148520	21939
БДП-UB 1016 x 305 x 249-2LPB100-10c	249	980	300	16,5	26	30	317	3,075	481079	9818	11347	38,97	181	11754	784	1245	6,09	46	533837	10171	0,40	670,32	1334592	25427
БДП-UB 1016 x 305 x 272-2LPB100-10c	272	990	300	16,5	31	30	347	3,095	553846	11189	12824	39,96	185	14004	934	1470	6,35	46	607497	11522	0,40	727,82	1518742	28806
БДП-UB 1016 x 305 x 314-2LPB100-10c	314	1000	300	19,1	35,9	30	400	3,11	644211	12884	14851	40,11	213	16232	1082	1713	6,37	47	698921	13228	0,40	832,82	1747302	33070
БДП-UB 1016 x 305 x 350-2LPB100-10c	350	1008	302	21,1	40	30	445	3,13	722965	14345	16589	40,3	236	18460	1223	1941	6,44	48	778448	14695	0,40	918,23	1936438	36554
БДП-UB 1016 x 305 x 393-2LPB100-10c	393	1016	303	24,4	43,9	30	500	3,144	807688	15899	18539	40,18	271	20496	1353	2168	6,4	48	863971	16266	0,40	1022,65	2143849	40362
БДП-UB 1016 x 305 x 415-2LPB100-10c	415	1020	304	26	46	30	529	3,152	853121	16728	19571	40,17	289	21707	1428	2298	6,41	49	909772	17102	0,40	1074,58	2251911	42331
БДП-UB 1016 x 305 x 438-2LPB100-10c	438	1026	305	26,9	49	30	556	3,167	909177	17723	20746	40,43	300	23355	1531	2463	6,48	49	966303	18095	0,41	1128,71	2385932	44678
БДП-UB 1016 x 305 x 487* -2LPB100-10c	487	1036,3	308,5	30	54,1	30	620	3,195	1021884	19722	23206	40,6	335	26721	1732	2800	6,57	50	1079877	20102	0,41	1238,99	2643517	49210
БДП-UB 1016 x 305 x 494 -2LPB100-10c	494	1036	309	31	54	30	629	3,194	1027959	19845	23413	40,42	345	26824	1736	2818	6,53	50	1085960	20231	0,41	1254,59	2655159	49465

Note. Symbols for beams used in the Table 9.5.2

БДП-UB 610 × 305 × 238-2LPB100-10c

Where: БДП – is a beam type – the H-beam, hot rolled;

UB 610 × 305 × 238- is a beam grade according to a standard document. 610 – beam height in mm; 305 – beam width in mm; 238 – weight of a linear meter in kg;

2 or 4 - the number of sets of connectors per one beam, installed in one or two of its decks accordingly;2

LPB100-10– the connector type used.

With this 100 – distance between connected beams, c - type of welding a beam to a connector (butt welding).

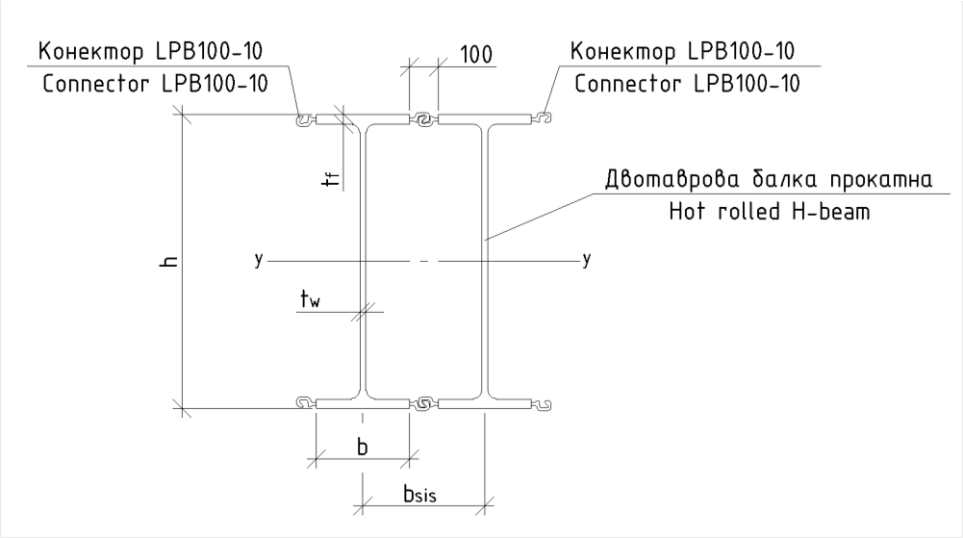


Fig.9.5.2.1 Cross-section of БДП beam using hot rolled steel according to EN10034 and 4 connectors LPB100-10

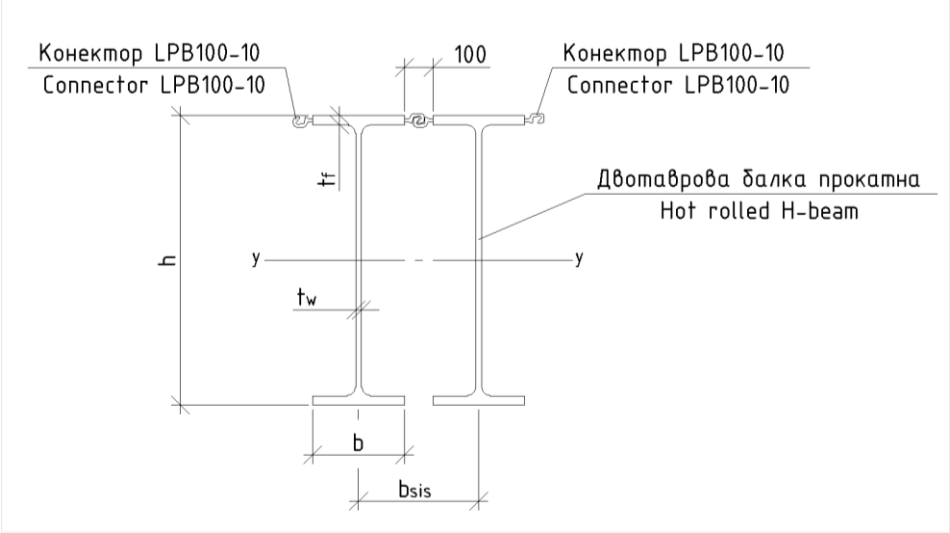


Fig.9.5.2.2 Cross-section of БДП beam using hot rolled steel according to EN10034 and 2 connectors LPB100-10

Table 9.5.3 a) H-beams in compliance with EN10034 applying MF – M140/F40 connectors, two-flange connected(Fig. 9.5.3.1)

Characteristics of Hot rolled H-beams																		Characteristics of welded sections			**Combination**			
Combination name	Weight	Cross-sectional height	Flange thickness	Flange thickness	Web thickness	Conjugation radius	Cross-sectional area	Surface area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	Shear area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
	G, kg/m	h, mm	b, mm	t_w,mm	t_f, mm	r, mm	A, cm^2	m^2/m	I_y, cm^4	W_y cm^3	$W_{pl,y}$, cm^3	i_y ,cm	A_{vz} , cm^2	I_z, cm^4	W_z, cm^3	$W_{pl,z}$, cm3	i_z, cm	cm	I_y, cm^4	Wy, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-UB 610 x 305 x 179-2MF-F40/M140-180c	179	620,2	307,1	14,1	23,6	17	228	2,412	153024	4935	5547	25,9	94,2	11408	743	1144	7,07	31,01	218965	7061	0,49	483,18	449528	14496
БДП-UB 610 x 305 x 238-2MF-F40/M140-180c	238	635,8	311,4	18,4	31,4	17	303	2,452	209471	6589	7486	26,28	124	15837	1017	1574	7,23	31,79	277146	8718	0,49	599,02	563992	17741
БДП-UB 686 x 254 x 152-2MF-F40/M140-180c	152	687,5	254,5	13,2	21	15	194	2,341	150355	4374	5000	27,83	96,3	5784	455	710	5,46	34,38	232633	6768	0,43	479,53	535404	15575
БДП-UB 686 x 254 x 170-2MF-F40/M140-180c	170	692,9	255,8	14,5	23,7	15	217	2,354	170326	4916	5631	28,03	106	6630	518	811	5,53	34,65	253271	7310	0,44	519,41	581164	16775
БДП-UB 762 x 267 x 173-2MF-F40/M140-180c	173	762,2	266,7	14,3	21,6	17	220	2,534	205282	5387	6198	30,52	115	6850	514	807	5,58	38,11	306852	8052	0,45	513,45	686932	18025
БДП-UB 762 x 267 x 197-2MF-F40/M140-180c	197	769,8	268	15,6	25,4	17	251	2,552	239957	6234	7167	30,94	127	8175	610	959	5,71	38,49	342572	8900	0,45	565,53	764669	19867
БДП-UB 838 x 292 x 194-2MF-F40/M140-180c	194	840,7	292,4	14,7	21,7	18	247	2,791	279175	6641	7640	33,63	131	9066	620	974	6,06	42,04	403370	9596	0,47	529,97	853873	20313
БДП-UB 838 x 292 x 226-2MF-F40/M140-180c	227	850,9	293,8	16,1	26,8	18	289	2,814	339704	7985	9155	34,31	145	11360	773	1212	6,27	42,55	465449	10940	0,47	598,05	982375	23090
БДП-UB 914 x 305 x 201-2MF-F40/M140-180c	201	903	303,3	15,1	20,2	19	256	2,956	325254	7204	8351	35,65	144	9423	621	982	6,07	45,15	469539	10400	0,48	532,50	971526	21518
БДП-UB 914 x 305 x 224-2MF-F40/M140-180c	224	910,4	304,1	15,9	23,9	19	286	2,973	376413	8269	9535	36,3	153	11236	739	1163	6,27	45,52	521909	11465	0,48	579,13	1078101	23684
БДП-UB 914 x 305 x 238-2MF-F40/M140-180c	238	915	305	16,5	25,9	19	304	2,984	406472	8885	10231	36,59	160	12285	806	1267	6,36	45,75	552822	12084	0,49	606,92	1139839	24915
БДП-UB 914 x 305 x 253-2MF-F40/M140-180c	253	918,4	305,5	17,3	27,9	19	323	2,991	436304	9501	10942	36,76	168	13301	871	1371	6,42	45,92	583115	12698	0,49	637,19	1201061	26156
БДП-UB 914 x 305 x 271-2MF-F40/M140-180c	271	923	307	18,4	30	19	346	3,004	471633	10220	11784	36,91	179	14518	946	1491	6,48	46,15	619269	13419	0,49	672,19	1271600	27554
БДП-UB 914 x 305 x 289-2MF-F40/M140-180c	289	926,6	307,7	19,5	32	19	368	3,012	504187	10883	12570	37	190	15597	1014	1601	6,51	46,33	652352	14081	0,49	708,13	1337610	28871
БДП-UB 914 x 305 x 313-2MF-F40/M140-180c	313	932	309	21,1	34,5	19	398	3,025	548297	11766	13630	37,1	206	17039	1103	1748	6,54	46,60	697424	14966	0,49	755,33	1426225	30606
БДП-UB 914 x 305 x 345-2MF-F40/M140-180c	345	943	308	22,1	39,9	19	440	3,041	625645	13269	15349	37,72	218	19515	1267	2003	6,66	47,15	776638	16472	0,49	822,45	1591471	33753
БДП-UB 914 x 419 x 343-2MF-F40/M140-180c	343	911,8	418,5	19,4	32	24	437	3,417	625779	13726	15477	37,83	191	39156	1871	2890	9,46	45,59	769085	16870	0,60	667,26	1285021	28186
БДП-UB 914 x 419 x 388-2MF-F40/M140-180c	388	921	420,5	21,4	36,6	24	494	3,44	719635	15627	17665	38,16	212	45438	2161	3341	9,59	46,05	864443	18772	0,60	739,98	1439538	31260
БДП-UB 1016 x 305 x 222-2MF-F40/M140-180c	222	970	300	16	21,1	30	283	3,056	407667	8405	9803	37,97	172	9546	636	1020	5,81	48,50	574354	11842	0,48	579,91	1196572	24672
БДП-UB 1016 x 305 x 249-2MF-F40/M140-180c	249	980	300	16,5	26	30	317	3,075	481079	9818	11347	38,97	181	11754	784	1245	6,09	49,00	649562	13256	0,48	636,16	1353254	27617
БДП-UB 1016 x 305 x 272-2MF-F40/M140-180c	272	990	300	16,5	31	30	347	3,095	553846	11189	12824	39,96	185	14004	934	1470	6,35	49,50	724099	14628	0,48	684,08	1508539	30476
БДП-UB 1016 x 305 x 314-2MF-F40/M140-180c	314	1000	300	19,1	35,9	30	400	3,11	644211	12884	14851	40,11	213	16232	1082	1713	6,37	50,00	816279	16326	0,48	771,58	1700580	34012
БДП-UB 1016 x 305 x 350-2MF-F40/M140-180c	350	1008	302	21,1	40	30	445	3,13	722965	14345	16589	40,3	236	18460	1223	1941	6,44	50,40	896427	17786	0,48	843,06	1859807	36901
БДП-UB 1016 x 305 x 393-2MF-F40/M140-180c	393	1016	303	24,4	43,9	30	500	3,144	807688	15899	18539	40,18	271	20496	1353	2168	6,4	50,80	982622	19343	0,48	930,35	2034413	40048
БДП-UB 1016 x 305 x 415-2MF-F40/M140-180c	415	1020	304	26	46	30	529	3,152	853121	16728	19571	40,17	289	21707	1428	2298	6,41	51,00	1028739	20171	0,48	973,88	2125493	41676
БДП-UB 1016 x 305 x 438-2MF-F40/M140-180c	438	1026	305	26,9	49	30	556	3,167	909177	17723	20746	40,43	300	23355	1531	2463	6,48	51,30	1085878	21167	0,49	1019,29	2238923	43644
БДП-UB 1016 x 305 x 487* -2MF-F40/M140-180c	487	1036,3	308,5	30	54,1	30	620	3,195	1021884	19722	23206	40,6	335	26721	1732	2800	6,57	51,82	1200470	23168	0,49	1112,30	2457461	47428
БДП-UB 1016 x 305 x 494 -2MF-F40/M140-180c	494	1036	309	31	54	30	629	3,194	1027959	19845	23413	40,42	345	26824	1736	2818	6,53	51,80	1206472	23291	0,49	1125,47	2467223	47630

Table 9.5.3 b) H-beams in compliance with EN10034 applying MF – M140/F40 connectors, one-flange connected (Fig. 9.5.3.2)

Characteristics of Hot rolled H-beams																		Characteristics of welded sections			**Combination**			
Combination name	Weight	Cross-sectional height	Flange thickness	Flange thickness	Web thickness	Conjugation radius	Cross-sectional area	Surface area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	Shear area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
	G, kg/m	h, mm	b, mm	t_w,mm	t_f, mm	r, mm	A, cm^2	m^2/m	I_y, cm^4	W_y cm^3	$W_{pl.y}$, cm^3	i_y ,cm	A_{vz} , cm^2	I_z, cm^4	W_z, cm^3	$W_{pl.z}$, cm3	i_z, cm	cm	I_y, cm^4	W_y, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-UB 610 x 305 x 179-MF-F40/M140-180c	179	620,2	307,1	14,1	23,6	17	228	2,412	153024	4935	5547	25,9	94,2	11408	743	1144	7,07	27	181400	5157	0,49	425,33	372408	10588
БДП-UB 610 x 305 x 238-MF-F40/M140-180c	238	635,8	311,4	18,4	31,4	17	303	2,452	209471	6589	7486	26,28	124	15837	1017	1574	7,23	29	239630	6831	0,49	541,67	487647	13901
БДП-UB 686 x 254 x 152-MF-F40/M140-180c	152	687,5	254,5	13,2	21	15	194	2,341	150355	4374	5000	27,83	96,3	5784	455	710	5,46	29	184910	4656	0,43	414,68	425570	10716
БДП-UB 686 x 254 x 170-MF-F40/M140-180c	170	692,9	255,8	14,5	23,7	15	217	2,354	170326	4916	5631	28,03	106	6630	518	811	5,53	30	205762	5207	0,44	454,75	472149	11947
БДП-UB 762 x 267 x 173-MF-F40/M140-180c	173	762,2	266,7	14,3	21,6	17	220	2,534	205282	5387	6198	30,52	115	6850	514	807	5,58	33	248761	5726	0,45	450,37	556885	12819
БДП-UB 762 x 267 x 197-MF-F40/M140-180c	197	769,8	268	15,6	25,4	17	251	2,552	239957	6234	7167	30,94	127	8175	610	959	5,71	34	284677	6579	0,45	502,63	635440	14685
БДП-UB 838 x 292 x 194-MF-F40/M140-180c	194	840,7	292,4	14,7	21,7	18	247	2,791	279175	6641	7640	33,63	131	9066	620	974	6,06	37	333186	7034	0,47	470,32	705306	14889
БДП-UB 838 x 292 x 226-MF-F40/M140-180c	227	850,9	293,8	16,1	26,8	18	289	2,814	339704	7985	9155	34,31	145	11360	773	1212	6,27	38	395444	8374	0,47	538,58	834623	17674
БДП-UB 914 x 305 x 201-MF-F40/M140-180c	201	903	303,3	15,1	20,2	19	256	2,956	325254	7204	8351	35,65	144	9423	621	982	6,07	40	388290	7655	0,48	474,20	803414	15839
БДП-UB 914 x 305 x 224-MF-F40/M140-180c	224	910,4	304,1	15,9	23,9	19	286	2,973	376413	8269	9535	36,3	153	11236	739	1163	6,27	40	440831	8712	0,48	520,92	910620	17997
БДП-UB 914 x 305 x 238-MF-F40/M140-180c	238	915	305	16,5	25,9	19	304	2,984	406472	8885	10231	36,59	160	12285	806	1267	6,36	41	471710	9327	0,49	548,82	972599	19231
БДП-UB 914 x 305 x 253-MF-F40/M140-180c	253	918,4	305,5	17,3	27,9	19	323	2,991	436304	9501	10942	36,76	168	13301	871	1371	6,42	41	502168	9945	0,49	579,15	1034332	20483
БДП-UB 914 x 305 x 271-MF-F40/M140-180c	271	923	307	18,4	30	19	346	3,004	471633	10220	11784	36,91	179	14518	946	1491	6,48	42	538323	10667	0,49	614,33	1105385	21904
БДП-UB 914 x 305 x 289-MF-F40/M140-180c	289	926,6	307,7	19,5	32	19	368	3,012	504187	10883	12570	37	190	15597	1014	1601	6,51	42	571504	11336	0,49	650,36	1171836	23243
БДП-UB 914 x 305 x 313-MF-F40/M140-180c	313	932	309	21,1	34,5	19	398	3,025	548297	11766	13630	37,1	206	17039	1103	1748	6,54	43	616521	12228	0,49	697,71	1260779	25007
БДП-UB 914 x 305 x 345-MF-F40/M140-180c	345	943	308	22,1	39,9	19	440	3,041	625645	13269	15349	37,72	218	19515	1267	2003	6,66	44	695287	13726	0,49	764,71	1424769	28128
БДП-UB 914 x 419 x 343-MF-F40/M140-180c	343	911,8	418,5	19,4	32	24	437	3,417	625779	13726	15477	37,83	191	39156	1871	2890	9,46	42	691841	14112	0,60	620,18	1155959	23579
БДП-UB 914 x 419 x 388-MF-F40/M140-180c	388	921	420,5	21,4	36,6	24	494	3,44	719635	15627	17665	38,16	212	45438	2161	3341	9,59	43	786996	16018	0,60	693,05	1310568	26675
БДП-UB 1016 x 305 x 222-MF-F40/M140-180c	222	970	300	16	21,1	30	283	3,056	407667	8405	9803	37,97	172	9546	636	1020	5,81	43	481377	8917	0,48	521,21	1002870	18576
БДП-UB 1016 x 305 x 249-MF-F40/M140-180c	249	980	300	16,5	26	30	317	3,075	481079	9818	11347	38,97	181	11754	784	1245	6,09	44	556519	10309	0,48	577,46	1159414	21476
БДП-UB 1016 x 305 x 272-MF-F40/M140-180c	272	990	300	16,5	31	30	347	3,095	553846	11189	12824	39,96	185	14004	934	1470	6,35	45	630773	11655	0,48	625,37	1314110	24281
БДП-UB 1016 x 305 x 314-MF-F40/M140-180c	314	1000	300	19,1	35,9	30	400	3,11	644211	12884	14851	40,11	213	16232	1082	1713	6,37	46	722963	13368	0,48	712,87	1506173	27850
БДП-UB 1016 x 305 x 350-MF-F40/M140-180c	350	1008	302	21,1	40	30	445	3,13	722965	14345	16589	40,3	236	18460	1223	1941	6,44	47	803040	14839	0,48	784,60	1666059	30787
БДП-UB 1016 x 305 x 393-MF-F40/M140-180c	393	1016	303	24,4	43,9	30	500	3,144	807688	15899	18539	40,18	271	20496	1353	2168	6,4	47	889130	16420	0,48	872,01	1840849	33996
БДП-UB 1016 x 305 x 415-MF-F40/M140-180c	415	1020	304	26	46	30	529	3,152	853121	16728	19571	40,17	289	21707	1428	2298	6,41	48	935192	17260	0,48	915,66	1932214	35660
БДП-UB 1016 x 305 x 438-MF-F40/M140-180c	438	1026	305	26,9	49	30	556	3,167	909177	17723	20746	40,43	300	23355	1531	2463	6,48	48	992017	18253	0,49	961,19	2045395	37635
БДП-UB 1016 x 305 x 487* -MF-F40/M140-180c	487	1036,3	308,5	30	54,1	30	620	3,195	1021884	19722	23206	40,6	335	26721	1732	2800	6,57	49	1106150	20266	0,49	1054,61	2264380	41486
БДП-UB 1016 x 305 x 494 -MF-F40/M140-180c	494	1036	309	31	54	30	629	3,194	1027959	19845	23413	40,42	345	26824	1736	2818	6,53	49	1112258	20398	0,49	1067,85	2274557	41713

Note. Symbols for beams used in the Table 9.5.3:

БДП-UB 610 × 305 × 179-MF-F40/M140-180c

Where: БДП – is a beam type – the H-beam, hot rolled;

UB 610 × 305 × 179- is a beam grade according to a standard document. 610 – beam height in mm; 305 - beam width in mm; 179 – weight of a linear meter in kg;

1 or 2 - - the number of sets of MF connectors per one beam, installed in one or two of its decks accordingly; F40/M140– the connector types used.

With this 180 – distance between connected beams, c - type of welding a beam to a connector (butt welding).

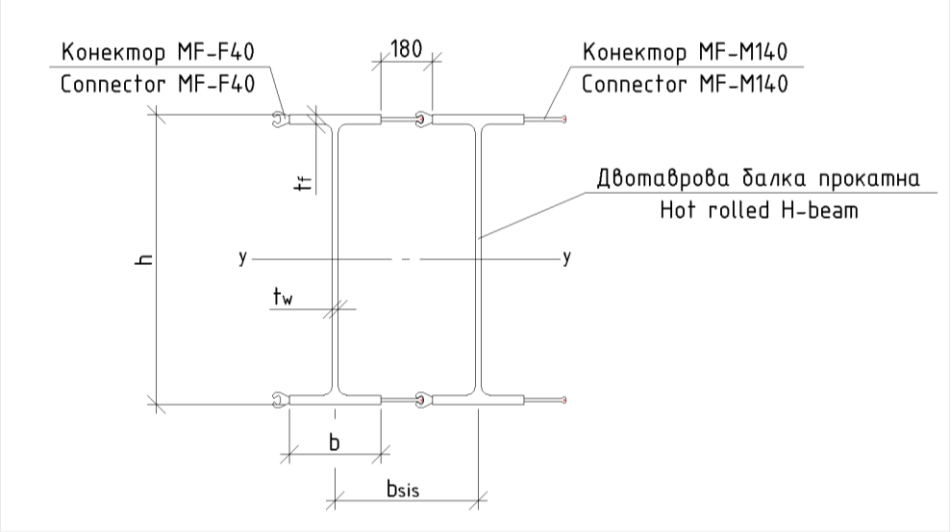


Fig.9.5.3.1 Cross-section of БДП beam using hot rolled steel according to EN10034 and 2 MF-F40/M140 connectors sets

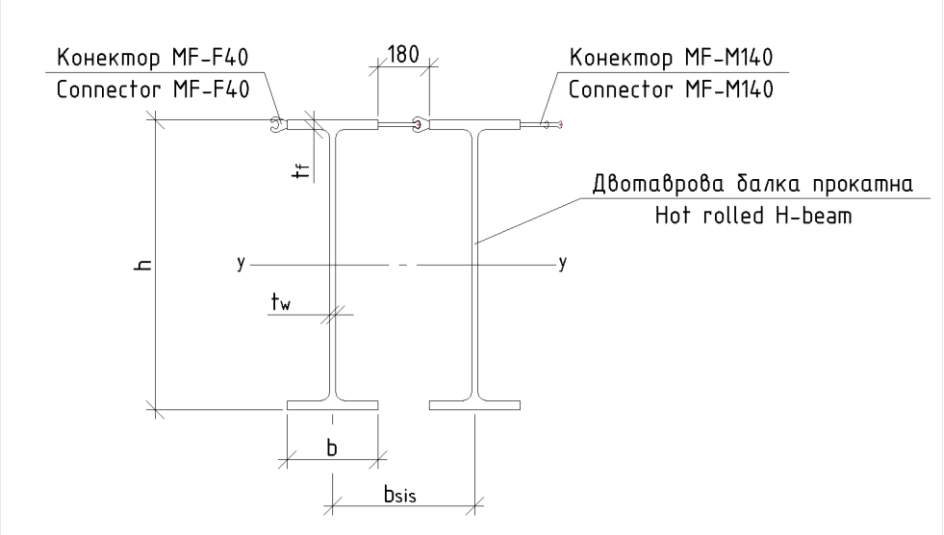


Fig.9.5.3.2 Cross-section of БДП beam using hot rolled steel according to EN10034 and one MF-F40/M140 connectors set

Table 9.5.4 a) H-beams in compliance with EN10034 applying MF – M90/F90 connectors, two-flange connected(Fig. 9.5.4.1)

Characteristics of Hot rolled H-beams																		Characteristics of welded sections			**Combination**			
Combination name	Weight	Cross-sectional height	Flange thickness	Flange thickness	Web thickness	Conjugation radius	Cross-sectional area	Surface area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	Shear area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
	G, kg/m	h, mm	b, mm	t_w,mm	t_f, mm	r, mm	A, cm^2	m^2/m	I_y, cm^4	W_y cm^3	$W_{pl,y}$, cm^3	i_y ,cm	A_{vz} , cm^2	I_z, cm^4	W_z, cm^3	$W_{pl,z}$, cm3	i_z, cm	cm	I_y, cm^4	W_y, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-UB 914 x 305 x 253-2MF-F90/M90-100н	253	918,4	305,5	17,3	27,9	19	323	2,991	436304	9501	10942	36,76	168	13301	871	1371	6,42	45,92	566333	12333	0,41	758,74	1396629	30414
БДП-UB 914 x 305 x 271-2MF-F90/M90-100н	271	923	307	18,4	30	19	346	3,004	471633	10220	11784	36,91	179	14518	946	1491	6,48	46,15	601784,2624	13039,74566	0,41	800,17	1478585	32039
БДП-UB 914 x 305 x 289-2MF-F90/M90-100н	289	926,6	307,7	19,5	32	19	368	3,012	504187	10883	12570	37	190	15597	1014	1601	6,51	46,33	634216,0073	13689,10009	0,41	842,95	1555595	33576
БДП-UB 914 x 305 x 313-2MF-F90/M90-100н	313	932	309	21,1	34,5	19	398	3,025	548297	11766	13630	37,1	206	17039	1103	1748	6,54	46,6	678448,2624	14558,97559	0,41	898,95	1658798	35597
БДП-UB 914 x 305 x 345-2MF-F90/M90-100н	345	943	308	22,1	39,9	19	440	3,041	625645	13269	15349	37,72	218	19515	1267	2003	6,66	47,15	755857,4115	16030,91011	0,41	979,58	1852592	39291
БДП-UB 914 x 419 x 343-2MF-F90/M90-100н	343	911,8	418,5	19,4	32	24	437	3,417	625779	13726	15477	37,83	191	39156	1871	2890	9,46	45,59	751324,9761	16480,03896	0,52	766,96	1449036	31784
БДП-UB 914 x 419 x 388-2MF-F90/M90-100н	388	921	420,5	21,4	36,6	24	494	3,44	719635	15627	17665	38,16	212	45438	2161	3341	9,59	46,05	845180,9761	18353,54997	0,52	850,47	1623787	35261
БДП-UB 1016 x 305 x 222-2MF-F90/M90-100н	222	970	300	16	21,1	30	283	3,056	407667	8405	9803	37,97	172	9546	636	1020	5,81	48,5	558382,464	11513,04049	0,40	691,67	1395956	28783
БДП-UB 1016 x 305 x 249-2MF-F90/M90-100н	249	980	300	16,5	26	30	317	3,075	481079	9818	11347	38,97	181	11754	784	1245	6,09	49	631860,2688	12895,10753	0,40	759,17	1579651	32238
БДП-UB 1016 x 305 x 272-2MF-F90/M90-100н	272	990	300	16,5	31	30	347	3,095	553846	11189	12824	39,96	185	14004	934	1470	6,35	49,5	704627,2688	14234,89432	0,40	816,67	1761568	35587
БДП-UB 1016 x 305 x 314-2MF-F90/M90-100н	314	1000	300	19,1	35,9	30	400	3,11	644211	12884	14851	40,11	213	16232	1082	1713	6,37	50	795058,0879	15901,16176	0,40	921,67	1987645	39753
БДП-UB 1016 x 305 x 350-2MF-F90/M90-100н	350	1008	302	21,1	40	30	445	3,13	722965	14345	16589	40,3	236	18460	1223	1941	6,44	50,4	873746,2688	17336,23549	0,40	1006,64	2173498	43125
БДП-UB 1016 x 305 x 393-2MF-F90/M90-100н	393	1016	303	24,4	43,9	30	500	3,144	807688	15899	18539	40,18	271	20496	1353	2168	6,4	50,8	958535,0879	18868,80094	0,40	1110,84	2378499	46821
БДП-UB 1016 x 305 x 415-2MF-F90/M90-100н	415	1020	304	26	46	30	529	3,152	853121	16728	19571	40,17	289	21707	1428	2298	6,41	51	1003902,269	19684,35821	0,40	1162,55	2484907	48724
БДП-UB 1016 x 305 x 438-2MF-F90/M90-100н	438	1026	305	26,9	49	30	556	3,167	909177	17723	20746	40,43	300	23355	1531	2463	6,48	51,3	1059958,269	20661,95456	0,41	1216,47	2617181	51017
БДП-UB 1016 x 305 x 487* -2MF-F90/M90-100н	487	1036,3	308,5	30	54,1	30	620	3,195	1021884	19722	23206	40,6	335	26721	1732	2800	6,57	51,815	1172698,177	22632,40715	0,41	1326,00	2870742	55404
БДП-UB 1016 x 305 x 494 -2MF-F90/M90-100н	494	1036	309	31	54	30	629	3,194	1027959	19845	23413	40,42	345	26824	1736	2818	6,53	51,8	1178740,269	22755,60364	0,41	1341,49	2882006	55637

Table 9.5.4 b) H-beams in compliance with EN10034 applying MF – M90/F90 connectors, one-flange connected(Fig. 9.5.4.2)

Characteristics of Hot rolled H-beams																		Characteristics of welded sections			**Combination**			
Combination name	Weight	Cross-sectional height	Flange thickness	Flange thickness	Web thickness	Conjugation radius	Cross-sectional area	Surface area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	Shear area	Moment of inertia	Section modulus	Plastic section modulus	Radius of inertia	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
	G, kg/m	h, mm	b, mm	t_w,mm	t_f, mm	r, mm	A, cm^2	m^2/m	I_y, cm^4	W_y cm^3	$W_{pl,y}$, cm^3	i_y ,cm	A_{vz} , cm^2	I_z, cm^4	W_z, cm^3	$W_{pl,z}$, cm3	i_z, cm	cm	I_y, cm^4	W_y, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-UB 914 x 305 x 253-MF-F90/M90-100н	253	918,4	305,5	17,3	27,9	19	323	2,991	436304	9501	10942	36,76	168	13301	871	1371	6,42	41,7	494811	9861	0,41	691,33	1220250	24318
БДП-UB 914 x 305 x 271-MF-F90/M90-100н	271	923	307	18,4	30	19	346	3,004	471633	10220	11784	36,91	179	14518	946	1491	6,48	42,1	530591	10580	0,41	733,01	1303663	25994
БДП-UB 914 x 305 x 289-MF-F90/M90-100н	289	926,6	307,7	19,5	32	19	368	3,012	504187	10883	12570	37	190	15597	1014	1601	6,51	42,5	563423	11243	0,41	775,90	1381954	27577
БДП-UB 914 x 305 x 313-MF-F90/M90-100н	313	932	309	21,1	34,5	19	398	3,025	548297	11766	13630	37,1	206	17039	1103	1748	6,54	43,1	607988	12130	0,41	832,11	1486524	29658
БДП-UB 914 x 305 x 345-MF-F90/M90-100н	345	943	308	22,1	39,9	19	440	3,041	625645	13269	15349	37,72	218	19515	1267	2003	6,66	43,9	685840	13618	0,41	912,58	1680979	33378
БДП-UB 914 x 419 x 343-MF-F90/M90-100н	343	911,8	418,5	19,4	32	24	437	3,417	625779	13726	15477	37,83	191	39156	1871	2890	9,46	42,4	683786	14022	0,52	714,24	1318778	27044
БДП-UB 914 x 419 x 388-MF-F90/M90-100н	388	921	420,5	21,4	36,6	24	494	3,44	719635	15627	17665	38,16	212	45438	2161	3341	9,59	43,2	778155	15919	0,52	797,95	1495014	30584
БДП-UB 1016 x 305 x 222-MF-F90/M90-100н	222	970	300	16	21,1	30	283	3,056	407667	8405	9803	37,97	172	9546	636	1020	5,81	43,3	474540	8844	0,40	623,34	1186351	22110
БДП-UB 1016 x 305 x 249-MF-F90/M90-100н	249	980	300	16,5	26	30	317	3,075	481079	9818	11347	38,97	181	11754	784	1245	6,09	44,3	548799	10227	0,40	690,84	1371998	25567
БДП-UB 1016 x 305 x 272-MF-F90/M90-100н	272	990	300	16,5	31	30	347	3,095	553846	11189	12824	39,96	185	14004	934	1470	6,35	45,2	622167	11565	0,40	748,34	1555418	28913
БДП-UB 1016 x 305 x 314-MF-F90/M90-100н	314	1000	300	19,1	35,9	30	400	3,11	644211	12884	14851	40,11	213	16232	1082	1713	6,37	46,2	713422	13267	0,40	853,34	1783555	33167
БДП-UB 1016 x 305 x 350-MF-F90/M90-100н	350	1008	302	21,1	40	30	445	3,13	722965	14345	16589	40,3	236	18460	1223	1941	6,44	47,0	792727	14729	0,40	938,64	1971957	36639
БДП-UB 1016 x 305 x 393-MF-F90/M90-100н	393	1016	303	24,4	43,9	30	500	3,144	807688	15899	18539	40,18	271	20496	1353	2168	6,4	47,7	878058	16299	0,40	1043,01	2178805	40445
БДП-UB 1016 x 305 x 415-MF-F90/M90-100н	415	1020	304	26	46	30	529	3,152	853121	16728	19571	40,17	289	21707	1428	2298	6,41	48,1	923720	17134	0,40	1094,89	2286435	42410
БДП-UB 1016 x 305 x 438-MF-F90/M90-100н	438	1026	305	26,9	49	30	556	3,167	909177	17723	20746	40,43	300	23355	1531	2463	6,48	48,5	979994	18121	0,41	1148,97	2419739	44744
БДП-UB 1016 x 305 x 487* -MF-F90/M90-100н	487	1036,3	308,5	30	54,1	30	620	3,195	1021884	19722	23206	40,6	335	26721	1732	2800	6,57	49,3	1093163	20123	0,41	1259,08	2676042	49261
БДП-UB 1016 x 305 x 494 -MF-F90/M90-100н	494	1036	309	31	54	30	629	3,194	1027959	19845	23413	40,42	345	26824	1736	2818	6,53	49,3	1099278	20254	0,41	1274,66	2687722	49521

Note. Symbols for beams used in the Table 9.5.4:

БДП-UB 914 × 305 × 253-MF-F90/M90-100н

Where: БДП – is a beam type – the H-beam, hot rolled;

UB 610 × 305 × 253- is a beam grade according to a standard document. 610 – beam height in mm; 305 - beam width in mm; 253– weight of a linear meter in kg;

1 or 2 - the number of sets of MF connectors per one beam, installed in one or two of its decks accordingly;.

F90/M90– the connector types used.

With this 100 – distance between connected beams, н - type of welding a beam to a connector (overlap).

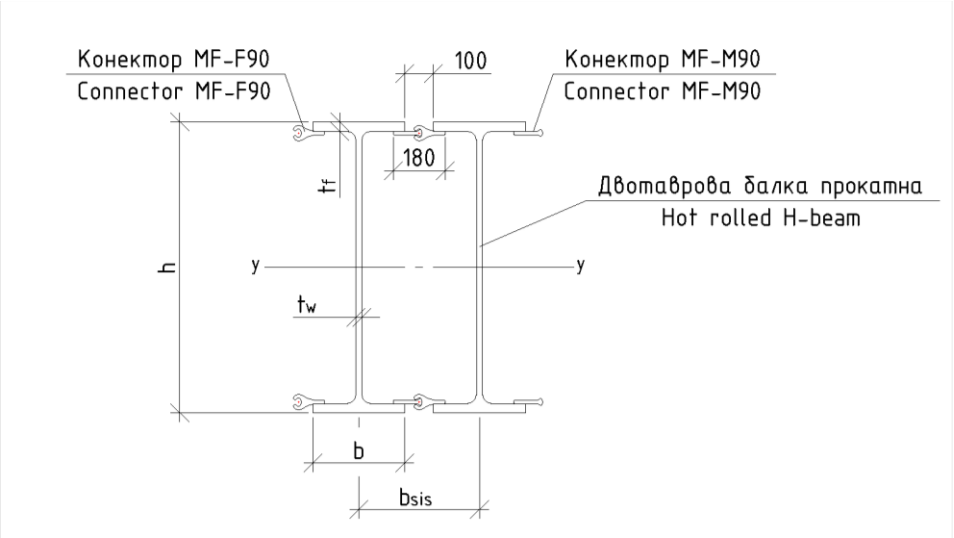


Fig.9.5.4.1 Cross-section of БДП beam using hot rolled steel according to EN10034 and 2 MF-F90/M90 connectors sets

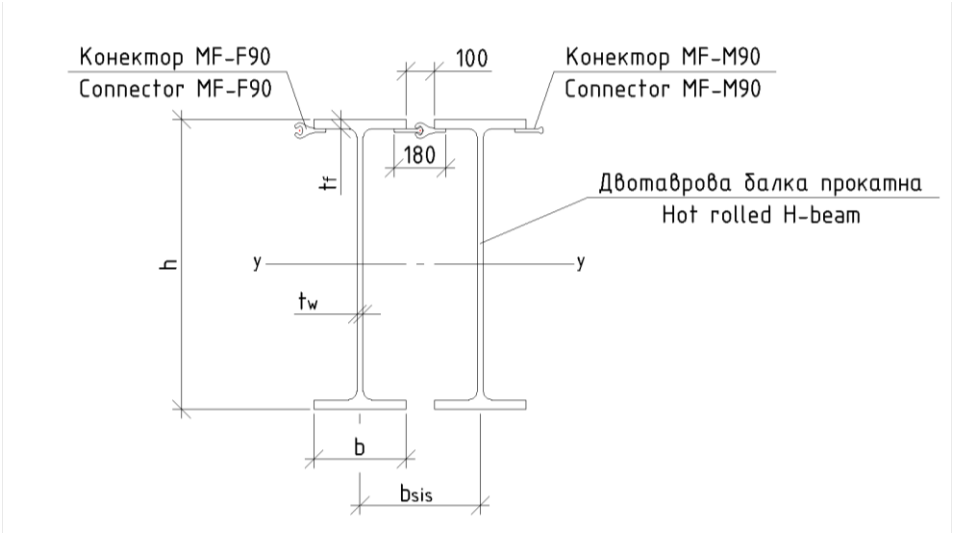


Fig.9.5.4.2 Cross-section of БДП beam using hot rolled steel according to EN10034 and one MF-F90/M90 connectors set

Table 9.5.5 a) H-beams in compliance with Specification ТУ У 01412851.001-95, which may be produced in Ukraine, applying connectors LPB180-12, two-flange connected(Fig. 9.5.5.1)

Characteristics of Hot rolled H-beams																Characteristics of welded sections			**Combination**			
Combination name	Beam type	Depth of a cross section	Width of a cross section	Web thickness	Flange thickness	Radius of root fillet	Cross-section area	Weight	Moment of inertia	Section modulus	First moment of area	Radius of gyration	Moment of inertia	Section modulus	Radius of gyration	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h,mm	b,mm	s,mm	t,mm	R,mm	cm^2	kg/m	Iy, cm^4	Wy, cm^3	Sy, cm^3	iy,mm	Iz, cm^4	Wz, cm^3	iz,mm	cm	Iy, cm4	Wy, cm3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-70Ш1-4LPB180-12	70Ш1	692	300	13	20	28	211,49	166	172435	4984	2814,6	28,55	9022,9	601,5	6,53	34,60	255909	7396	0,5	444,52	511818	14792
БДП-70Ш2-4LPB180-12	70Ш2	698	300	15	23	28	242,53	190,4	198791	5696	3233,6	28,63	10381,1	692,1	6,54	34,90	283012	8109	0,5	493,32	566023	16218
БДП-70Ш3-4LPB180-12	70Ш3	707	300	18	27,8	28	289,09	226,9	239032	6762	3867,2	28,76	12422,4	828,2	6,56	35,35	324303	9174	0,5	566,32	648606	18348
БДП-70Ш4-4LPB180-12	70Ш4	715	300	20,5	31,5	28	329,39	258,6	275138	7696	4426,7	28,9	14240,2	949,3	6,58	35,75	361492	10112	0,5	629,72	722983	20223
БДП-80Ш2-4LPB180-12	80Ш2	792	300	14	22	28	243,45	191,1	253655	6405	3644,1	32,28	9928,9	661,9	6,39	39,60	363232	9173	0,5	494,72	726464	18345
БДП-90Ш1-4LPB180-12	90Ш1	881	299	15	18,5	28	243,96	191,5	292583	6642	3861,2	34,63	8278,5	553,7	5,83	44,05	430053	9763	0,5	495,52	860106	19526
БДП-90Ш2-4LPB180-12	90Ш2	890	299	15	23	28	270,87	212,6	345335	7760	4457	35,71	10283,3	687,8	6,16	44,50	484243	10882	0,5	537,72	968485	21764
БДП-100Ш1-4LPB180-12	100Ш1	990	320	16	21	30	293,8	230,6	446039	9011	5234,1	38,96	11517,9	719,9	6,26	49,50	619538	12516	0,5	573,72	1239076	25032
БДП-100Ш2-4LPB180-12	100Ш2	998	320	17	25	30	328,88	258,2	516373	10348	5982,6	39,62	13710	856,9	6,46	49,90	691307	13854	0,5	628,92	1382614	27708
БДП-100Ш3-4LPB180-12	100Ш3	1006	320	18	29	30	363,96	285,7	587730	11685	6736,2	40,18	15903	993,9	6,61	50,30	764105	15191	0,5	683,92	1528210	30382
БДП-100Ш4-4LPB180-12	100Ш4	1013	320	19,5	32,5	30	400,58	314,5	655449	12941	7470	40,45	17828,8	1114,3	6,67	50,65	833089	16448	0,5	741,52	1666179	32896

Table 9.5.5 b) H-beams in compliance with Specification ТУ У 01412851.001-95, which may be produced in Ukraine, applying connectors LPB180-12, one-flange connected(Fig. 9.5.5.2)

Characteristics of Hot rolled H-beams																Characteristics of welded sections			**Combination**			
Combination name	Beam type	Depth of a cross section	Width of a cross section	Web thickness	Flange thickness	Radius of root fillet	Cross-section area	Weight	Moment of inertia	Section modulus	First moment of area	Radius of gyration	Moment of inertia	Section modulus	Radius of gyration	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h,mm	b,mm	s,mm	t,mm	R,mm	cm^2	kg/m	Iy, cm^4	Wy, cm^3	Sy, cm^3	iy,mm	Iz, cm^4	Wz, cm^3	iz,mm	cm	Iy, cm4	Wy, cm3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-70Ш1-2LPB180-12	70Ш1	692	300	13	20	28	211,49	166	172435	4984	2814,6	28,55	9022,9	601,5	6,53	29,60	207970	5252	0,5	388,26	415940	10504
БДП-70Ш2-2LPB180-12	70Ш2	698	300	15	23	28	242,53	190,4	198791	5696	3233,6	28,63	10381,1	692,1	6,54	30,44	235339	5979	0,5	437,06	470678	11958
БДП-70Ш3-2LPB180-12	70Ш3	707	300	18	27,8	28	289,09	226,9	239032	6762	3867,2	28,76	12422,4	828,2	6,56	31,50	276840	7063	0,5	510,06	553680	14125
БДП-70Ш4-2LPB180-12	70Ш4	715	300	20,5	31,5	28	329,39	258,6	275138	7696	4426,7	28,9	14240,2	949,3	6,58	32,30	313964	8010	0,5	573,46	627927	16020
БДП-80Ш2-2LPB180-12	80Ш2	792	300	14	22	28	243,45	191,1	253655	6405	3644,1	32,28	9928,9	661,9	6,39	34,53	301229	6743	0,5	438,46	602458	13486
БДП-90Ш1-2LPB180-12	90Ш1	881	299	15	18,5	28	243,96	191,5	292583	6642	3861,2	34,63	8278,5	553,7	5,83	38,38	352282	7085	0,5	439,26	704565	14170
БДП-90Ш2-2LPB180-12	90Ш2	890	299	15	23	28	270,87	212,6	345335	7760	4457	35,71	10283,3	687,8	6,16	39,30	406457	8178	0,5	481,46	812914	16356
БДП-100Ш1-2LPB180-12	100Ш1	990	320	16	21	30	293,8	230,6	446039	9011	5234,1	38,96	11517,9	719,9	6,26	44,09	523102	9526	0,5	517,46	1046205	19053
БДП-100Ш2-2LPB180-12	100Ш2	998	320	17	25	30	328,88	258,2	516373	10348	5982,6	39,62	13710	856,9	6,46	44,99	595010	10855	0,5	572,66	1190020	21711
БДП-100Ш3-2LPB180-12	100Ш3	1006	320	18	29	30	363,96	285,7	587730	11685	6736,2	40,18	15903	993,9	6,61	45,80	667794	12186	0,5	627,66	1335588	24371
БДП-100Ш4-2LPB180-12	100Ш4	1013	320	19,5	32,5	30	400,58	314,5	655449	12941	7470	40,45	17828,8	1114,3	6,67	46,51	736772	13447	0,5	685,26	1473544	26895

Note. Before starting the design, it is necessary to find out the capability of Ukrainian steel mills to produce specific steel grades. Symbols for beams used in the Table 9.5.5

БДП-70Ш1-2 (or 4) LPB180-12

Where: БДП – is a beam type – the H-beam, hot rolled;

70Ш1 - is a beam grade according to a standard document, 70 – beam height in cm;

2 or 4 - the number of sets of connectors per one beam, installed in one or two of its decks accordingly;

LPB180-12– the connector type used.

With this 180 – – distance between connected beams, c - type of welding a beam to a connector (butt welding).

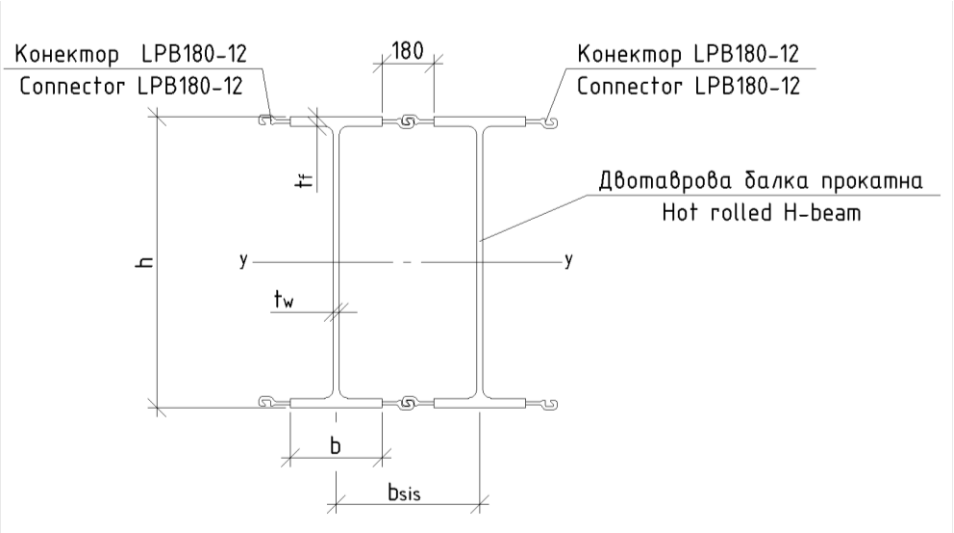


Fig.9.5.5.1 Cross-section of БДП beam using hot rolled steel according to Specification ТУ У 01412851.001-95 and 4 connectors LPB180-12

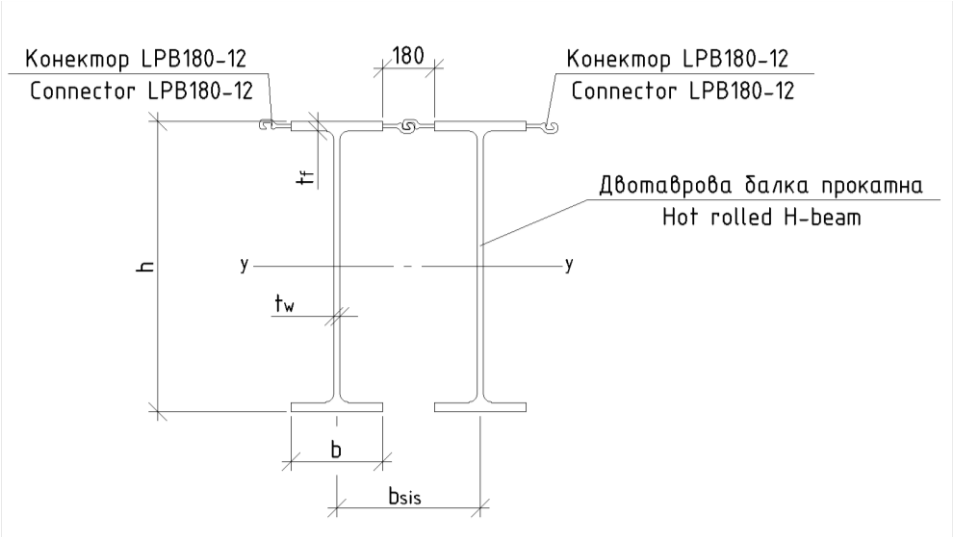


Fig.9.5.5.2 Cross-section of БДП beam using hot rolled steel according to Specification ТУ У 01412851.001-95 and 2 connectors LPB180-12

Table 9.5.6 a) H-beams in compliance with Specification ТУ У 01412851.001-95, which may be produced in Ukraine, applying connectors MF- M140/F40, two-flange connected(Fig. 9.5.6.1)

Characteristics of Hot rolled H-beams																Characteristics of welded sections			**Combination**			
Combination name	Beam type	Depth of a cross section	Width of a cross section	Web thickness	Flange thickness	Radius of root fillet	Cross-section area	Weight	Moment of inertia	Section modulus	First moment of area	Radius of gyration	Moment of inertia	Section modulus	Radius of gyration	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h,mm	b,mm	t_w,mm	t_f,mm	R,mm	A,cm^2	kg/m	Iy, cm^4	Wy, cm^3	Sy, cm^3	iy,mm	Iz, cm^4	Wz, cm^3	iz,mm	cm	I_y, cm^4	Wy, cm^3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-70Ш1-2MF -F40/M140	70Ш1	692	300	13	20	28	211,49	166	172435	4984	2814,6	28,55	9022,9	601,5	6,53	34,60	256075	7401	0,5	444,71	512150	14802
БДП-70Ш2-2MF -F40/M140	70Ш2	698	300	15	23	28	242,53	190,4	198791	5696	3233,6	28,63	10381,1	692,1	6,54	34,90	283179	8114	0,5	493,51	566357	16228
БДП-70Ш3-2MF -F40/M140	70Ш3	707	300	18	27,8	28	289,09	226,9	239032	6762	3867,2	28,76	12422,4	828,2	6,56	35,35	324472	9179	0,5	566,51	648944	18358
БДП-70Ш4-2MF -F40/M140	70Ш4	715	300	20,5	31,5	28	329,39	258,6	275138	7696	4426,7	28,9	14240,2	949,3	6,58	35,75	361662	10116	0,5	629,91	723325	20233
БДП-80Ш2-2MF -F40/M140	80Ш2	792	300	14	22	28	243,45	191,1	253655	6405	3644,1	32,28	9928,9	661,9	6,39	39,60	363443	9178	0,5	494,91	726886	18356
БДП-90Ш1-2MF -F40/M140	90Ш1	881	299	15	18,5	28	243,96	191,5	292583	6642	3861,2	34,63	8278,5	553,7	5,83	44,05	430312	9769	0,5	495,71	860624	19537
БДП-90Ш2-2MF -F40/M140	90Ш2	890	299	15	23	28	270,87	212,6	345335	7760	4457	35,71	10283,3	687,8	6,16	44,50	484504	10888	0,5	537,91	969008	21775
БДП-100Ш1-2MF -F40/M140	100Ш1	990	320	16	21	30	293,8	230,6	446039	9011	5234,1	38,96	11517,9	719,9	6,26	49,50	619859	12522	0,5	573,91	1239719	25045
БДП-100Ш2-2MF -F40/M140	100Ш2	998	320	17	25	30	328,88	258,2	516373	10348	5982,6	39,62	13710	856,9	6,46	49,90	691631	13860	0,5	629,11	1383261	27721
БДП-100Ш3-2MF -F40/M140	100Ш3	1006	320	18	29	30	363,96	285,7	587730	11685	6736,2	40,18	15903	993,9	6,61	50,30	764431	15197	0,5	684,11	1528862	30395
БДП-100Ш4-2MF -F40/M140	100Ш4	1013	320	19,5	32,5	30	400,58	314,5	655449	12941	7470	40,45	17828,8	1114,3	6,67	50,65	833418	16454	0,5	741,71	1666835	32909

Table 9.5.6 b)H-beams in compliance with Specification ТУ У 01412851.001-95, which may be produced in Ukraine, applying connectors MF- M140/F40, one-flange connected(Fig. 9.5.6.2)

Characteristics of Hot rolled H-beams																Characteristics of welded sections			**Combination**			
Combination name	Beam type	Depth of a cross section	Width of a cross section	Web thickness	Flange thickness	Radius of root fillet	Cross-section area	Weight	Moment of inertia	Section modulus	First moment of area	Radius of gyration	Moment of inertia	Section modulus	Radius of gyration	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h,mm	b,mm	t_w,mm	t_f,mm	R,mm	A,cm^2	kg/m	Iy, cm^4	Wy, cm^3	Sy, cm^3	iy,mm	Iz, cm^4	Wz, cm^3	iz,mm	cm	Iy, cm4	Wy, cm3	b_{sys},m	G97%	I_{sys}, cm^4	W_{sys},cm^3
БДП-70Ш1-MF-F40/M140	70Ш1	692	300	13	20	28	211,49	166	172435	4984	2814,6	28,55	9022,9	601,5	6,53	29,60	208033	5253	0,5	388,36	416067	10506
БДП-70Ш2-MF-F40/M140	70Ш2	698	300	15	23	28	242,53	190,4	198791	5696	3233,6	28,63	10381,1	692,1	6,54	30,432	235404	5980	0,5	437,16	397582	11392
БДП-70Ш3-MF-F40/M140	70Ш3	707	300	18	27,8	28	289,09	226,9	239032	6762	3867,2	28,76	12422,4	828,2	6,56	31,496	276909	7063	0,5	510,16	478064	13524
БДП-70Ш4-MF-F40/M140	70Ш4	715	300	20,5	31,5	28	329,39	258,6	275138	7696	4426,7	28,9	14240,2	949,3	6,58	32,298	314035	8011	0,5	573,56	550276	15392
БДП-80Ш2-MF-F40/M140	80Ш2	792	300	14	22	28	243,45	191,1	253655	6405	3644,1	32,28	9928,9	661,9	6,39	34,52	301311	6744	0,5	438,56	507310	12811
БДП-90Ш1-MF-F40/M140	90Ш1	881	299	15	18,5	28	243,96	191,5	292583	6642	3861,2	34,63	8278,5	553,7	5,83	38,37	352383	7086	0,5	439,36	585166	13284
БДП-90Ш2-MF-F40/M140	90Ш2	890	299	15	23	28	270,87	212,6	345335	7760	4457	35,71	10283,3	687,8	6,16	39,289	406560	8179	0,5	481,56	690670	15521
БДП-100Ш1-MF-F40/M140	100Ш1	990	320	16	21	30	293,8	230,6	446039	9011	5234,1	38,96	11517,9	719,9	6,26	44,08	523231	9527	0,5	517,56	892078	18022
БДП-100Ш2-MF-F40/M140	100Ш2	998	320	17	25	30	328,88	258,2	516373	10348	5982,6	39,62	13710	856,9	6,46	44,979	595143	10856	0,5	572,76	1032746	20696
БДП-100Ш3-MF-F40/M140	100Ш3	1006	320	18	29	30	363,96	285,7	587730	11685	6736,2	40,18	15903	993,9	6,61	45,791	667930	12187	0,5	627,76	1175460	23369
БДП-100Ш4-MF-F40/M140	100Ш4	1013	320	19,5	32,5	30	400,58	314,5	655449	12941	7470	40,45	17828,8	1114,3	6,67	46,504	736911	13448	0,5	685,36	1310898	25881

Note. Before starting the design, it is necessary to find out the capability of Ukrainian steel mills to produce specific steel grades. Symbols for beams used in the Table 9.5.6

БДП-70Ш1-MF (or 2MF)- F40/M140

Where: БДП – is a beam type – the H-beam, hot rolled;

70Ш1 - is a beam grade according to a standard document, 70 – beam height in cm;

1 or 2 - the number of sets of connectors per one beam, installed in one or two of its decks accordingly;

F40/M140 – the connector type used.

With this 180 – – distance between connected beams, c - type of welding a beam to a connector (butt welding).

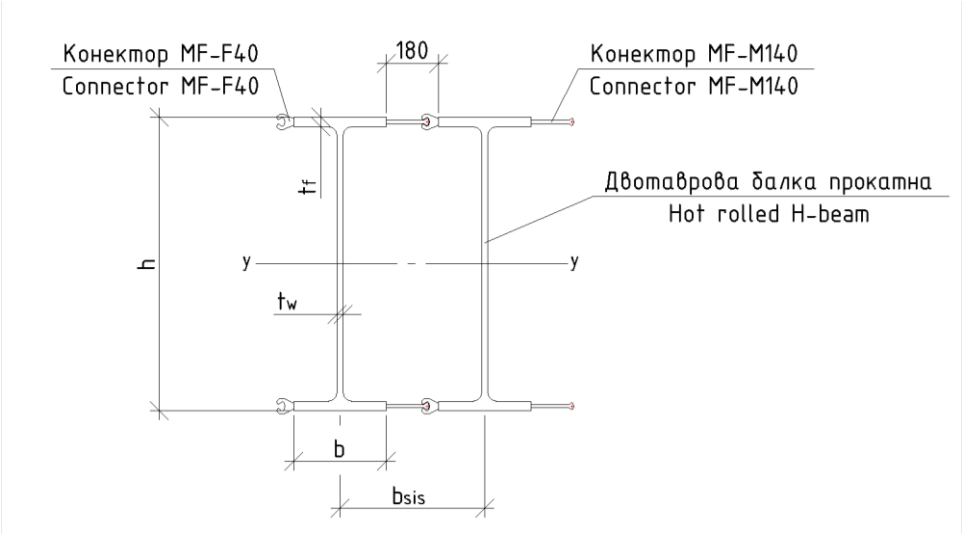


Fig.9.5.6.1 Cross-section of БДП beam using hot rolled steel according to Specification ТУ У 01412851.001-95 and 2 connectors MF-F40/M140 sets

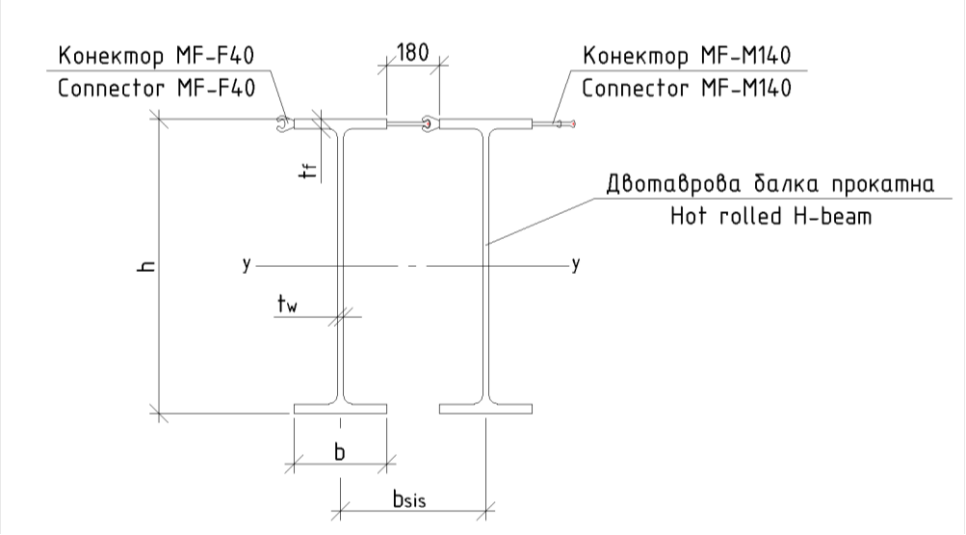


Fig.9.5.6.2 Cross-section of БДП beam using hot rolled steel according to Specification ТУ У 01412851.001-95 and one connector MF-F40/M140 set

9.6 Attachment 6. Characteristics of H-beams made of rolled sheet metal, which may be produced in Ukraine.

Table 9.6.1 a) Data for LPB180-12 connectors applying, two-flange connected(Fig. 9.6.1.1)

Characteristics of welded H-beams															Characteristics of welded sections			**Combination**			
Combination name	**Beam type**	**Depth of a cross section**	**Width of a cross section**	**Web thickness**	**Flange thickness**	**Cross-section area**	**Weight**	**Moment of inertia**	**Section modulus**	**First moment of area**	**Radius of gyration**	**Moment of inertia**	**Section modulus**	**Radius of gyration**	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h.mm	b.mm	t w mm	t f. mm	A.cm^2	kg/m	Iy. cm^4	Wy. cm^3	Sy. cm^3	iy.mm	Iz. cm^4	Wz. cm^3	iz.mm	cm	Iy, cm^4	Wy. cm^3	bsys.m	G97%	Isys. cm^4	Wsys.cm^3
БДЗ-778х367х20/18-4LPB180-12	778х367х18	778,0	367,0	18,0	20,0	279,6	219,5	271206	6972	40,1	311,0	16513	900	77,0	38,90	368625	9476	0,55	504,13	673902	17324
БДЗ-778х419х20/18-4LPB180-12	778х419х18	778,0	419,0	18,0	20,0	300,4	235,8	301090	7740	44,0	317,0	24556	1172	90,0	38,90	398509	10244	0,60	487,58	665290	17103
БДЗ-778х491х20/18-4LPB180-12	778х491х18	778,0	491,0	18,0	20,0	329,2	258,5	342469	8804	49,5	323,0	39493	1609	110,0	38,90	439887	11308	0,67	469,09	655569	16853
БДЗ-1035х367х22/18-4LPB180-12	1035х367х18	1035,0	367,0	18,0	22,0	294,3	231,0	293534	5672	42,9	316,0	18161	990	79,0	51,75	470632	9094	0,55	525,16	860387	16626
БДЗ-1035х367х25/18-4LPB180-12	1035х367х18	1035,0	367,0	18,0	25,0	360,8	283,2	611417	11815	68,2	412,0	20644	1125	76,0	51,75	786351	15195	0,55	620,59	1437571	27779
БДЗ-1035х367х25/20-4LPB180-12	1035х367х20	1035,0	367,0	20,0	25,0	380,5	298,7	627345	12123	70,6	406,0	20662	1126	74,0	51,75	802279	15503	0,55	648,92	1466689	28342
БДЗ-1035х367х25/22-4LPB180-12	1035х367х22	1035,0	367,0	22,0	25,0	400,2	314,2	643273	12430	73,0	401,0	20684	1127	72,0	51,75	818207	15811	0,55	677,26	1495808	28905
БДЗ-1035х419х25/18-4LPB180-12	1035х419х18	1035,0	419,0	18,0	25,0	386,8	303,6	677737	13096	74,7	419,0	30698	1465	89,0	51,75	852671	16477	0,60	600,77	1423491	27507
БДЗ-1035х419х25/20-4LPB180-12	1035х419х20	1035,0	419,0	20,0	25,0	406,5	319,1	693665	13404	77,2	413,0	30716	1466	87,0	51,75	868599	16785	0,60	626,64	1450082	28021
БДЗ-1035х419х25/22-4LPB180-12	1035х419х22	1035,0	419,0	22,0	25,0	426,2	334,6	709593	13712	79,6	408,0	30737	1467	85,0	51,75	884527	17092	0,60	652,52	1476673	28535
БДЗ-1035х491х25/18-4LPB180-12	1035х491х18	1035,0	491,0	18,0	25,0	422,8	331,9	769565	14871	83,8	427,0	49369	2011	108,0	51,75	944499	18251	0,67	578,48	1407599	27200
БДЗ-1035х491х25/20-4LPB180-12	1035х491х20	1035,0	491,0	20,0	25,0	442,5	347,4	785493	15179	86,2	421,0	49387	2012	106,0	51,75	960427	18559	0,67	601,58	1431337	27659
БДЗ-1035х491х25/22-4LPB180-12	1035х491х22	1035,0	491,0	22,0	25,0	462,2	362,8	801421	15486	88,7	416,0	49409	2013	103,0	51,75	976355	18867	0,67	624,53	1455074	28117
БДЗ-1035х738х25/18-4LPB180-12	1035х738х18	1035,0	738,0	18,0	25,0	546,3	428,8	1084585	20958	115,0	446,0	167526	4540	175,0	51,75	1259519	24339	0,92	528,39	1372025	26513
БДЗ-1035х738х25/20-4LPB180-12	1035х738х20	1035,0	738,0	20,0	25,0	566,0	444,3	1100513	21266	117,4	441,0	167544	4541	172,0	51,75	1275447	24646	0,92	545,27	1389376	26848
БДЗ-1035х738х25/22-4LPB180-12	1035х738х22	1035,0	738,0	22,0	25,0	585,7	459,8	1116441	21574	119,9	437,0	167565	4541	169,0	51,75	1291375	24954	0,92	562,16	1406727	27183

Table 9.6.1 b) Data for LPB180-12 connectors applying, one-flange connected(Fig. 9.6.1.2)

Characteristics of welded H-beams															Characteristics of welded sections			**Combination**			
Combination name	**Beam type**	**Depth of a cross section**	**Width of a cross section**	**Web thickness**	**Flange thickness**	**Cross-section area**	**Weight**	**Moment of inertia**	**Section modulus**	**First moment of area**	**Radius of gyration**	**Moment of inertia**	**Section modulus**	**Radius of gyration**	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h.mm	b.mm	t_w mm	$t_{f.}$ mm	A.cm2	kg/m	Iy. cm4	Wy. cm3	Sy. cm3	iy.mm	Iz. cm4	Wz. cm3	iz.mm	cm	Iy, cm^4	Wy. cm^3	bsys.m	G97%	Isys. cm^4	Wsys.cm^3
БДЗ-778х367х20/18-2LPB180-12	778х367х18	778,0	367,0	18,0	20,0	279,6	219,5	271206	6972	40,1	311,0	16513	900	77,0	34,66	314234	7285	0,55	452,71	574468	13317
БДЗ-778х419х20/18-2LPB180-12	778х419х18	778,0	419,0	18,0	20,0	300,4	235,8	301090	7740	44,0	317,0	24556	1172	90,0	34,92	344469	8034	0,60	440,62	575073	13413
БДЗ-778х491х20/18-2LPB180-12	778х491х18	778,0	491,0	18,0	20,0	329,2	258,5	342469	8804	49,5	323,0	39493	1609	110,0	35,24	386266	9075	0,67	427,17	575658	13525
БДЗ-1035х367х22/18-2LPB180-12	1035х367х18	1035,0	367,0	18,0	22,0	294,3	231,0	293534	5672	42,9	316,0	18161	990	79,0	46,29	372211	6506	0,55	473,73	680458	11894
БДЗ-1035х367х25/18-2LPB180-12	1035х367х18	1035,0	367,0	18,0	25,0	360,8	283,2	611417	11815	68,2	412,0	20644	1125	76,0	47,23	690763	12276	0,55	569,16	1262821	22443
БДЗ-1035х367х25/20-2LPB180-12	1035х367х20	1035,0	367,0	20,0	25,0	380,5	298,7	627345	12123	70,6	406,0	20662	1126	74,0	47,44	707074	12614	0,55	597,50	1292640	23060
БДЗ-1035х367х25/22-2LPB180-12	1035х367х22	1035,0	367,0	22,0	25,0	400,2	314,2	643273	12430	73,0	401,0	20684	1127	72,0	47,64	723351	12949	0,55	625,83	1322396	23673
БДЗ-1035х419х25/18-2LPB180-12	1035х419х18	1035,0	419,0	18,0	25,0	386,8	303,6	677737	13096	74,7	419,0	30698	1465	89,0	47,51	757581	13530	0,60	553,81	1264743	22588
БДЗ-1035х419х25/20-2LPB180-12	1035х419х20	1035,0	419,0	20,0	25,0	406,5	319,1	693665	13404	77,2	413,0	30716	1466	87,0	47,70	773848	13868	0,60	579,68	1291900	23151
БДЗ-1035х419х25/22-2LPB180-12	1035х419х22	1035,0	419,0	22,0	25,0	426,2	334,6	709593	13712	79,6	408,0	30737	1467	85,0	47,87	790086	14202	0,60	605,56	1319008	23710
БДЗ-1035х491х25/18-2LPB180-12	1035х491х18	1035,0	491,0	18,0	25,0	422,8	331,9	769565	14871	83,8	427,0	49369	2011	108,0	47,84	850006	15272	0,67	536,56	1266775	22759
БДЗ-1035х491х25/20-2LPB180-12	1035х491х20	1035,0	491,0	20,0	25,0	442,5	347,4	785493	15179	86,2	421,0	49387	2012	106,0	48,00	866223	15608	0,67	559,66	1290943	23261
БДЗ-1035х491х25/22-2LPB180-12	1035х491х22	1035,0	491,0	22,0	25,0	462,2	362,8	801421	15486	88,7	416,0	49409	2013	103,0	48,15	882416	15942	0,67	582,61	1315077	23759
БДЗ-1035х738х25/18-2LPB180-12	1035х738х18	1035,0	738,0	18,0	25,0	546,3	428,8	1084585	20958	115,0	446,0	167526	4540	175,0	48,67	1166514	21275	0,92	497,75	1270712	23175
БДЗ-1035х738х25/20-2LPB180-12	1035х738х20	1035,0	738,0	20,0	25,0	566,0	444,3	1100513	21266	117,4	441,0	167544	4541	172,0	48,77	1182623	21608	0,92	514,63	1288260	23538
БДЗ-1035х738х25/22-2LPB180-12	1035х738х22	1035,0	738,0	22,0	25,0	585,7	459,8	1116441	21574	119,9	437,0	167565	4541	169,0	48,86	1198720	21940	0,92	531,51	1305795	23900

Note. Symbols for beams: БД3-778×367×20/18-2(or 4)LPB180-12

Where:БД3 – is a beam type – the H-beam , welded;

778– beam height in mm; 367– beam width in mm; 20/18 –flange and web thickness,

2 or 4 - the number of sets of connectors per one beam, installed in one or two of its decks accordingly;

LPB180-12– the connector type used.

With this, 100 — distance between connected beams, н - type of welding a beam to a connector (overlap).

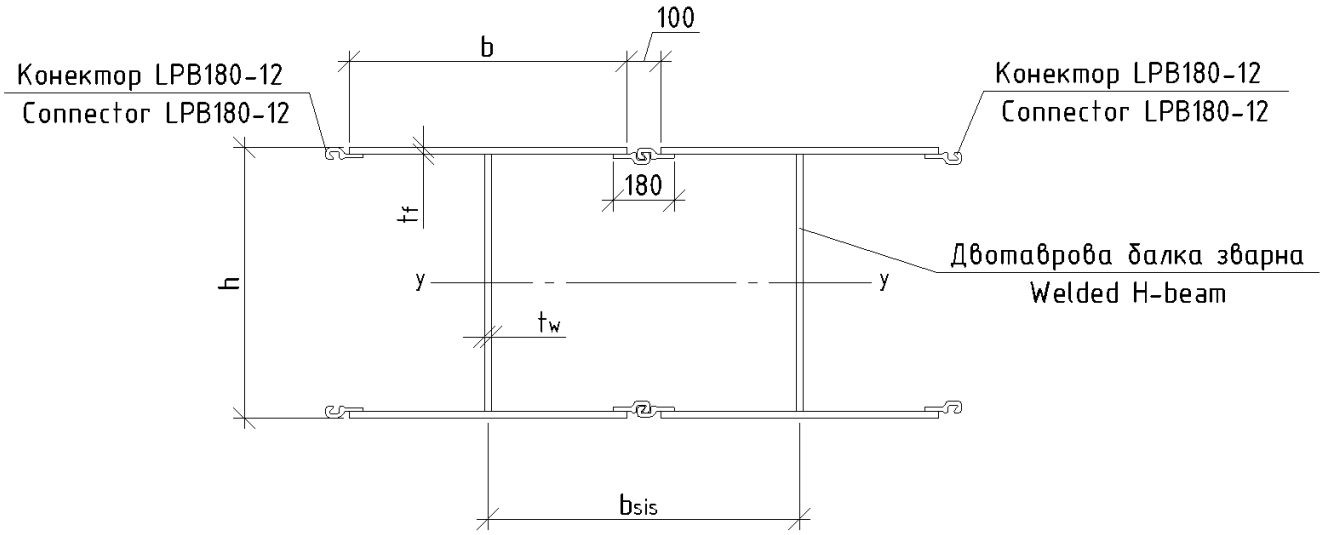


Fig.9.6.1.1 Cross-section of welded H-beam БД3 using rolled sheet metal and 4 connectors LPB180-12

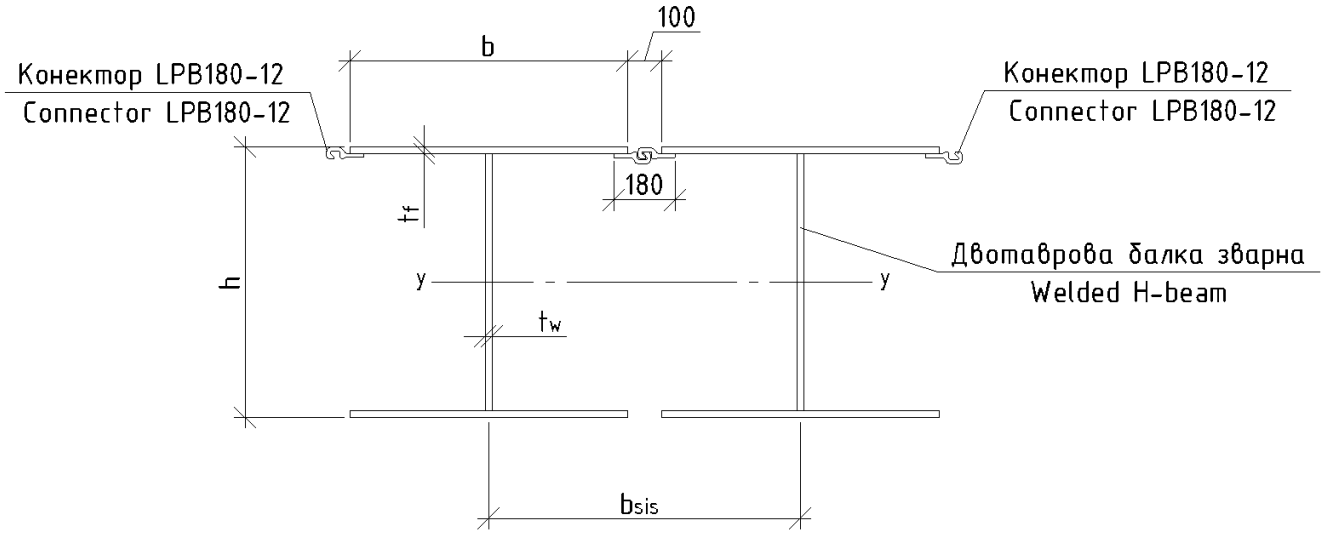


Fig.9.6.1.2 Cross-section of welded H-beam БД3 using rolled sheet metal and 2 connectors LPB180-12

Table 9.6.2 a) Cross-section of welded H-beam БДЗ using rolled sheet metal and 2 connectors LPB100-10, two-flange connected(Fig. 9.6.2.1)

Characteristics of welded H-beams															Characteristics of welded sections			Combination			
Combination name	**Beam type**	**Depth of a cross section**	**Width of a cross section**	**Web thickness**	**Flange thickness**	**Cross-section area**	**Weight**	**Moment of inertia**	**Section modulus**	**First moment of area**	**Radius of gyration**	**Moment of inertia**	**Section modulus**	**Radius of gyration**	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h.mm	b.mm	t_w mm	$t_{f.}$ mm	A.cm^2	kg/m	Iy. cm^4	Wy. cm^3	Sy. cm^3	iy.mm	Iz. cm^4	Wz. cm^3	iz.mm	cm	Iy, cm^4	Wy. cm^3	bsys.m	G97%	Isys. cm^4	Wsys.cm^3
БДЗ-778x367x20/18-4LPB100-10	778x367x18	778,0	367,0	18,0	20,0	279,6	219,5	271206	6972	40,1	311,0	16513	900	77,0	38,90	343447	8829	0,47	551,94	735433	18906
БДЗ-778x419x20/18-4LPB100-10	778x419x18	778,0	419,0	18,0	20,0	300,4	235,8	301090	7740	44,0	317,0	24556	1172	90,0	38,90	373331	9597	0,52	528,05	719328	18492
БДЗ-778x491x20/18-4LPB100-10	778x491x18	778,0	491,0	18,0	20,0	329,2	258,5	342469	8804	49,5	323,0	39493	1609	110,0	38,90	414710	10661	0,59	502,13	701708	18039
БДЗ-1035x367x22/18-4LPB100-10	1035x367x18	1035,0	367,0	18,0	22,0	294,3	231,0	293534	7507	42,9	316,0	18161	990	79,0	51,75	422499	8164	0,47	576,57	904710	17482
БДЗ-1035x367x25/18-4LPB100-10	1035x367x18	1035,0	367,0	18,0	25,0	360,8	283,2	611417	11815	68,2	412,0	20644	1125	76,0	51,75	739620	14292	0,47	688,34	1583769	30604
БДЗ-1035x367x25/20-4LPB100-10	1035x367x20	1035,0	367,0	20,0	25,0	380,5	298,7	627345	12123	70,6	406,0	20662	1126	74,0	51,75	755548	14600	0,47	721,53	1617875	31263
БДЗ-1035x367x25/22-4LPB100-10	1035x367x22	1035,0	367,0	22,0	25,0	400,2	314,2	643273	12430	73,0	401,0	20684	1127	72,0	51,75	771476	14908	0,47	754,73	1651982	31922
БДЗ-1035x419x25/18-4LPB100-10	1035x419x18	1035,0	419,0	18,0	25,0	386,8	303,6	677737	13096	74,7	419,0	30698	1465	89,0	51,75	805940	15574	0,52	658,68	1552871	30007
БДЗ-1035x419x25/20-4LPB100-10	1035x419x20	1035,0	419,0	20,0	25,0	406,5	319,1	693665	13404	77,2	413,0	30716	1466	87,0	51,75	821868	15882	0,52	688,55	1583561	30600
БДЗ-1035x419x25/22-4LPB100-10	1035x419x22	1035,0	419,0	22,0	25,0	426,2	334,6	709593	13712	79,6	408,0	30737	1467	85,0	51,75	837796	16189	0,52	718,41	1614250	31193
БДЗ-1035x491x25/18-4LPB100-10	1035x491x18	1035,0	491,0	18,0	25,0	422,8	331,9	769565	14871	83,8	427,0	49369	2011	108,0	51,75	897768	17348	0,59	626,32	1519066	29354
БДЗ-1035x491x25/20-4LPB100-10	1035x491x20	1035,0	491,0	20,0	25,0	442,5	347,4	785493	15179	86,2	421,0	49387	2012	106,0	51,75	913696	17656	0,59	652,55	1546016	29875
БДЗ-1035x491x25/22-4LPB100-10	1035x491x22	1035,0	491,0	22,0	25,0	462,2	362,8	801421	15486	88,7	416,0	49409	2013	103,0	51,75	929624	17964	0,59	678,61	1572967	30395
БДЗ-1035x738x25/18-4LPB100-10	1035x738x18	1035,0	738,0	18,0	25,0	546,3	428,8	1084585	20958	115,0	446,0	167526	4540	175,0	51,75	1212788	23436	0,84	557,35	1447241	27966
БДЗ-1035x738x25/20-4LPB100-10	1035x738x20	1035,0	738,0	20,0	25,0	566,0	444,3	1100513	21266	117,4	441,0	167544	4541	172,0	51,75	1228716	23743	0,84	575,84	1466248	28333
БДЗ-1035x738x25/22-4LPB100-10	1035x738x22	1035,0	738,0	22,0	25,0	585,7	459,8	1116441	21574	119,9	437,0	167565	4541	169,0	51,75	1244644	24051	0,84	594,34	1485255	28701

Table 9.6.2 b) Data for LPB100-10 connectors applying, one-flange connected(Fig. 9.6.2.2)

Characteristics of welded H-beams															Characteristics of welded sections			Combination			
Combination name	**Beam type**	**Depth of a cross section**	**Width of a cross section**	**Web thickness**	**Flange thickness**	**Cross-section area**	**Weight**	**Moment of inertia**	**Section modulus**	**First moment of area**	**Radius of gyration**	**Moment of inertia**	**Section modulus**	**Radius of gyration**	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h.mm	b.mm	t_w mm	$t_{f.}$ mm	A.cm^2	kg/m	Iy. cm^4	Wy. cm^3	Sy. cm^3	iy.mm	Iz. cm^4	Wz. cm^3	iz.mm	cm	Iy, cm^4	Wy. cm^3	bsys.m	G97%	Isys. cm^4	Wsys.cm^3
БДЗ-778x367x20/18-2LPB100-10	778x367x18	778,0	367,0	18,0	20,0	279,6	219,5	271206	6972	40,1	311,0	16513	900	77,0	35,78	304352	7242	0,47	510,98	651717	15508
БДЗ-778x419x20/18-2LPB100-10	778x419x18	778,0	419,0	18,0	20,0	300,4	235,8	301090	7740	44,0	317,0	24556	1172	90,0	35,98	334426	7996	0,52	491,19	644367	15406
БДЗ-778x491x20/18-2LPB100-10	778x491x18	778,0	491,0	18,0	20,0	329,2	258,5	342469	8804	49,5	323,0	39493	1609	110,0	36,21	376031	9042	0,59	469,76	636262	15300
БДЗ-1035x367x22/18-2LPB100-10	1035x367x18	1035,0	367,0	18,0	22,0	294,3	231,0	293534	5672	42,9	316,0	18161	990	79,0	47,77	352948	6333	0,47	535,61	755778	13561
БДЗ-1035x367x25/18-2LPB100-10	1035x367x18	1035,0	367,0	18,0	25,0	360,8	283,2	611417	11815	68,2	412,0	20644	1125	76,0	48,46	671348	12198	0,47	647,38	1437577	26120
БДЗ-1035x367x25/20-2LPB100-10	1035x367x20	1035,0	367,0	20,0	25,0	380,5	298,7	627345	12123	70,6	406,0	20662	1126	74,0	48,62	687479	12527	0,47	680,57	1472117	26825
БДЗ-1035x367x25/22-2LPB100-10	1035x367x22	1035,0	367,0	22,0	25,0	400,2	314,2	643273	12430	73,0	401,0	20684	1127	72,0	48,77	703590	12855	0,47	713,77	1506617	27527
БДЗ-1035x419x25/18-2LPB100-10	1035x419x18	1035,0	419,0	18,0	25,0	386,8	303,6	677737	13096	74,7	419,0	30698	1465	89,0	48,67	737932	13459	0,52	621,83	1421833	25932
БДЗ-1035x419x25/20-2LPB100-10	1035x419x20	1035,0	419,0	20,0	25,0	406,5	319,1	693665	13404	77,2	413,0	30716	1466	87,0	48,81	754038	13788	0,52	651,69	1452867	26566
БДЗ-1035x419x25/22-2LPB100-10	1035x419x22	1035,0	419,0	22,0	25,0	426,2	334,6	709593	13712	79,6	408,0	30737	1467	85,0	48,94	770129	14115	0,52	681,56	1483870	27197
БДЗ-1035x491x25/18-2LPB100-10	1035x491x18	1035,0	491,0	18,0	25,0	422,8	331,9	769565	14871	83,8	427,0	49369	2011	108,0	48,92	830073	15208	0,59	593,96	1404524	25732
БДЗ-1035x491x25/20-2LPB100-10	1035x491x20	1035,0	491,0	20,0	25,0	442,5	347,4	785493	15179	86,2	421,0	49387	2012	106,0	49,04	846153	15536	0,59	620,18	1431730	26288
БДЗ-1035x491x25/22-2LPB100-10	1035x491x22	1035,0	491,0	22,0	25,0	462,2	362,8	801421	15486	88,7	416,0	49409	2013	103,0	49,15	862220	15863	0,59	646,24	1458916	26841
БДЗ-1035x738x25/18-2LPB100-10	1035x738x18	1035,0	738,0	18,0	25,0	546,3	428,8	1084585	20958	115,0	446,0	167526	4540	175,0	49,53	1145870	21232	0,84	534,52	1367387	25336
БДЗ-1035x738x25/20-2LPB100-10	1035x738x20	1035,0	738,0	20,0	25,0	566,0	444,3	1100513	21266	117,4	441,0	167544	4541	172,0	49,60	1161892	21558	0,84	553,02	1386506	25726
БДЗ-1035x738x25/22-2LPB100-10	1035x738x22	1035,0	738,0	22,0	25,0	585,7	459,8	1116441	21574	119,9	437,0	167565	4541	169,0	49,67	1177907	21883	0,84	571,51	1405618	26114

Note. Symbols for beams: БДЗ-778×367×20/18-2(or 4) LPB100-10

Where:БДЗ – is a beam type – the H-beam , welded;

778– beam height in mm; 367– beam width in mm; 20/18 –flange and web thickness,

2 or 4 - the number of sets of connectors per one beam, installed in one or two of its decks accordingly;

LPB100-10– the connector type used.

With this, 100 — distance between connected beams, c - type of welding a beam to a connector (butt welding).

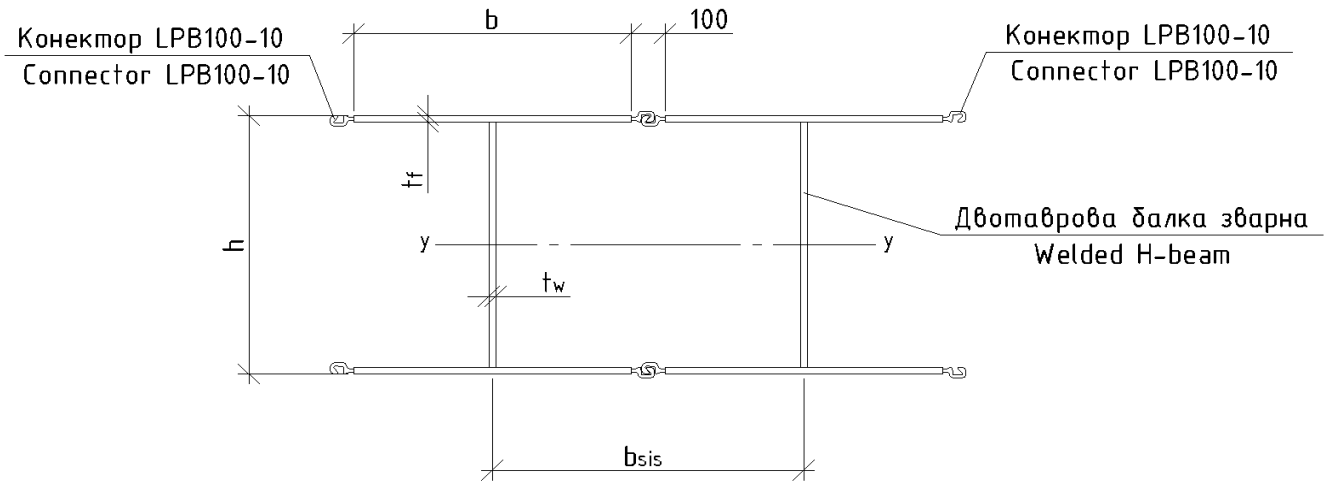


Fig.9.6.2.1 Cross-section of welded H-beam БДЗ using rolled sheet metal and 4 connectors LPB100-10

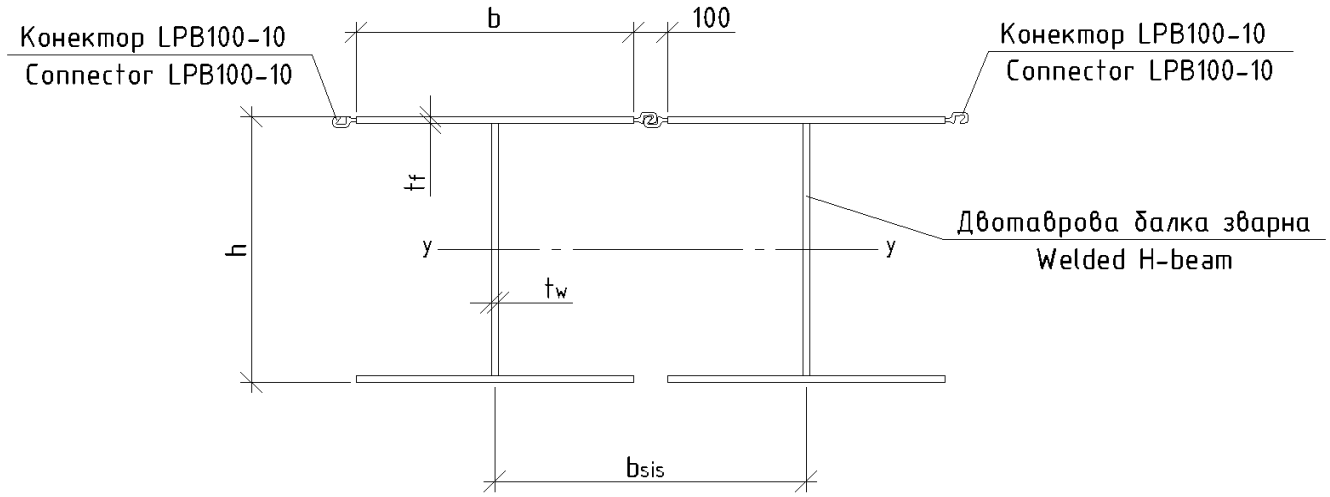


Fig.9.6.2.2 Cross-section of welded H-beam БДЗ using rolled sheet metal and 2 connectors LPB100-10

Table 9.6.3 a) Data for MF- M140/F40 connectors applying, two-flange connected(Fig. 9.6.3.1)

Characteristics of welded H-beams															Characteristics of welded sections			Combination			
Combination name	**Beam type**	**Depth of a cross section**	**Width of a cross section**	**Web thickness**	**Flange thickness**	**Cross-section area**	**Weight**	**Moment of inertia**	**Section modulus**	**First moment of area**	**Radius of gyration**	**Moment of inertia**	**Section modulus**	**Radius of gyration**	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h.mm	b.mm	t_w mm	$t_{f.}$ mm	A.cm^2	kg/m	Iy. cm^4	Wy. cm^3	Sy. cm^3	iy.mm	Iz. cm^4	Wz. cm^3	iz.mm	cm	Iy, cm^4	Wy. cm^3	bsys.m	G97%	Isys. cm^4	Wsys.cm^3
БДЗ-778x367x20/18-2MF-F40/M140-180c	778x367x18	778,0	367,0	18,0	20,0	279,6	219,5	271206	6971,9	40,1	311,0	16513	900	77,0	38,90	377601	9707	0,55	504,31	495806	17746
БДЗ-778x419x20/18-2MF-F40/M140-180c	778x419x18	778,0	419,0	18,0	20,0	300,4	235,8	301090	7740,1	44,0	317,0	24556	1172	90,0	38,90	407486	10475	0,60	487,74	502655	17488
БДЗ-778x491x20/18-2MF-F40/M140-180c	778x491x18	778,0	491,0	18,0	20,0	329,2	258,5	342469	8803,8	49,5	323,0	39493	1609	110,0	38,90	448864	11539	0,67	469,24	510385	17197
БДЗ-1035x367x22/18-2MF-F40/M140-180c	1035x367x18	1035,0	367,0	18,0	22,0	294,3	231,0	293534	7507,3	42,9	316,0	18161	990	79,0	51,75	483491	9343	0,55	525,33	536626	17080
БДЗ-1035x367x25/18-2MF-F40/M140-180c	1035x367x18	1035,0	367,0	18,0	25,0	360,8	283,2	611417	11814,8	68,2	412,0	20644	1125	76,0	51,75	800251	15464	0,55	620,76	1117765	28270
БДЗ-1035x367x25/20-2MF-F40/M140-180c	1035x367x20	1035,0	367,0	20,0	25,0	380,5	298,7	627345	12122,6	70,6	406,0	20662	1126	74,0	51,75	816179	15772	0,55	649,10	1146883	28833
БДЗ-1035x367x25/22-2MF-F40/M140-180c	1035x367x22	1035,0	367,0	22,0	25,0	400,2	314,2	643273	12430,4	73,0	401,0	20684	1127	72,0	51,75	832106	16079	0,55	677,44	1176002	29396
БДЗ-1035x419x25/18-2MF-F40/M140-180c	1035x419x18	1035,0	419,0	18,0	25,0	386,8	303,6	677737	13096,4	74,7	419,0	30698	1465	89,0	51,75	866571	16745	0,60	600,93	1131448	27955
БДЗ-1035x419x25/20-2MF-F40/M140-180c	1035x419x20	1035,0	419,0	20,0	25,0	406,5	319,1	693665	13404,2	77,2	413,0	30716	1466	87,0	51,75	882499	17053	0,60	626,81	1158039	28469
БДЗ-1035x419x25/22-2MF-F40/M140-180c	1035x419x22	1035,0	419,0	22,0	25,0	426,2	334,6	709593	13711,9	79,6	408,0	30737	1467	85,0	51,75	898427	17361	0,60	652,68	1184629	28983
БДЗ-1035x491x25/18-2MF-F40/M140-180c	1035x491x18	1035,0	491,0	18,0	25,0	422,8	331,9	769565	14870,8	83,8	427,0	49369	2011	108,0	51,75	958399	18520	0,67	578,62	1146893	27600
БДЗ-1035x491x25/20-2MF-F40/M140-180c	1035x491x20	1035,0	491,0	20,0	25,0	442,5	347,4	785493	15178,6	86,2	421,0	49387	2012	106,0	51,75	974326	18828	0,67	601,72	1170630	28059
БДЗ-1035x491x25/22-2MF-F40/M140-180c	1035x491x22	1035,0	491,0	22,0	25,0	462,2	362,8	801421	15486,4	88,7	416,0	49409	2013	103,0	51,75	990254	19135	0,67	624,68	1194368	28518
БДЗ-1035x738x25/18-2MF-F40/M140-180c	1035x738x18	1035,0	738,0	18,0	25,0	546,3	428,8	1084585	20958,2	115,0	446,0	167526	4540	175,0	51,75	1273419	24607	0,92	528,49	1181465	26805
БДЗ-1035x738x25/20-2MF-F40/M140-180c	1035x738x20	1035,0	738,0	20,0	25,0	566,0	444,3	1100513	21266	117,4	441,0	167544	4541	172,0	51,75	1289347	24915	0,92	545,38	1198816	27140
БДЗ-1035x738x25/22-2MF-F40/M140-180c	1035x738x22	1035,0	738,0	22,0	25,0	585,7	459,8	1116441	21573,7	119,9	437,0	167565	4541	169,0	51,75	1305274	25223	0,92	562,26	1216167	27476

Table 9.6.3 b) Data for MF- M140/F40 connectors applying, one-flange connected(Fig. 9.6.3.2)

Characteristics of welded H-beams															Characteristics of welded sections			Combination			
Combination name	**Beam type**	**Depth of a cross section**	**Width of a cross section**	**Web thickness**	**Flange thickness**	**Cross-section area**	**Weight**	**Moment of inertia**	**Section modulus**	**First moment of area**	**Radius of gyration**	**Moment of inertia**	**Section modulus**	**Radius of gyration**	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h.mm	b.mm	t_w mm	$t_{f.}$ mm	A.cm^2	kg/m	Iy. cm^4	Wy. cm^3	Sy. cm^3	iy.mm	Iz. cm^4	Wz. cm^3	iz.mm	cm	Iy, cm^4	Wy. cm^3	bsys.m	G97%	Isys. cm^4	Wsys.cm^3
БДЗ-778x367x20/18-MF-F40/M140-180c	778x367x18	778,0	367,0	18,0	20,0	279,6	219,5	271206	6972	40,1	311,0	16513	900	77,0	34,47	318190	7343	0,55	452,79	581701	13425
БДЗ-778x419x20/18-MF-F40/M140-180c	778x419x18	778,0	419,0	18,0	20,0	300,4	235,8	301090	7740	44,0	317,0	24556	1172	90,0	34,74	348458	8093	0,60	440,70	502655	13511
БДЗ-778x491x20/18-MF-F40/M140-180c	778x491x18	778,0	491,0	18,0	20,0	329,2	258,5	342469	8804	49,5	323,0	39493	1609	110,0	35,07	390295	9134	0,67	427,24	510385	13612
БДЗ-1035x367x22/18-MF-F40/M140-180c	1035x367x18	1035,0	367,0	18,0	22,0	294,3	231,0	293534	7507	42,9	316,0	18161	990	79,0	46,09	377908	6583	0,55	473,82	536626	12035
БДЗ-1035x367x25/18-MF-F40/M140-180c	1035x367x18	1035,0	367,0	18,0	25,0	360,8	283,2	611417	11815	68,2	412,0	20644	1125	76,0	47,05	697055	12349	0,55	569,25	1117765	22575
БДЗ-1035x367x25/20-MF-F40/M140-180c	1035x367x20	1035,0	367,0	20,0	25,0	380,5	298,7	627345	12123	70,6	406,0	20662	1126	74,0	47,27	713397	12688	0,55	597,58	1146883	23196
БДЗ-1035x367x25/22-MF-F40/M140-180c	1035x367x22	1035,0	367,0	22,0	25,0	400,2	314,2	643273	12430	73,0	401,0	20684	1127	72,0	47,48	729701	13025	0,55	625,92	1176002	23811
БДЗ-1035x419x25/18-MF-F40/M140-180c	1035x419x18	1035,0	419,0	18,0	25,0	386,8	303,6	677737	13096	74,7	419,0	30698	1465	89,0	47,34	763913	13603	0,60	553,89	1131448	22709
БДЗ-1035x419x25/20-MF-F40/M140-180c	1035x419x20	1035,0	419,0	20,0	25,0	406,5	319,1	693665	13404	77,2	413,0	30716	1466	87,0	47,54	780207	13941	0,60	579,76	1158039	23274
БДЗ-1035x419x25/22-MF-F40/M140-180c	1035x419x22	1035,0	419,0	22,0	25,0	426,2	334,6	709593	13712	79,6	408,0	30737	1467	85,0	47,72	796470	14278	0,60	605,64	1184629	23836
БДЗ-1035x491x25/18-MF-F40/M140-180c	1035x491x18	1035,0	491,0	18,0	25,0	422,8	331,9	769565	14871	83,8	427,0	49369	2011	108,0	47,69	856386	15343	0,67	536,63	1146893	22867
БДЗ-1035x491x25/20-MF-F40/M140-180c	1035x491x20	1035,0	491,0	20,0	25,0	442,5	347,4	785493	15179	86,2	421,0	49387	2012	106,0	47,85	872626	15681	0,67	559,73	1170630	23370
БДЗ-1035x491x25/22-MF-F40/M140-180c	1035x491x22	1035,0	491,0	22,0	25,0	462,2	362,8	801421	15486	88,7	416,0	49409	2013	103,0	48,01	888841	16017	0,67	582,68	1194368	23870
БДЗ-1035x738x25/18-MF-F40/M140-180c	1035x738x18	1035,0	738,0	18,0	25,0	546,3	428,8	1084585	20958	115,0	446,0	167526	4540	175,0	48,55	1173015	21345	0,92	497,80	1181465	23252
БДЗ-1035x738x25/20-MF-F40/M140-180c	1035x738x20	1035,0	738,0	20,0	25,0	566,0	444,3	1100513	21266	117,4	441,0	167544	4541	172,0	48,65	1189138	21680	0,92	514,68	1198816	23617
БДЗ-1035x738x25/22-MF-F40/M140-180c	1035x738x22	1035,0	738,0	22,0	25,0	585,7	459,8	1116441	21574	119,9	437,0	167565	4541	169,0	48,75	1205249	22013	0,92	531,57	1216167	23980

Note.Symbols for beams: БД3-778×367×20/18-MF(or 2 MF)-F40/M140-180c

Where:БД3 – is a beam type – the H-beam , welded;

778– beam height in mm; 367– beam width in mm; 20/18 –flange and web thickness,

MF or 2 MF - the number of sets of connectors per one beam, installed in one or two of its decks accordingly;

F90/M90 – the connector type used.

With this, 180 — distance between connected beams, c - type of welding a beam to a connector (butt welding).

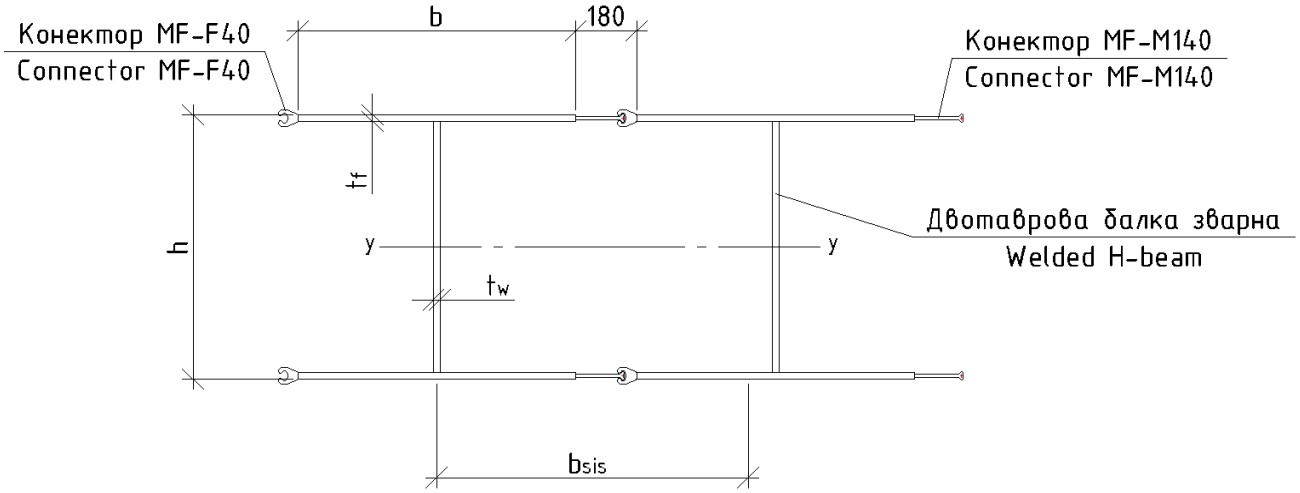


Fig.9.6.3.1 Cross-section of welded H-beam БД3 using rolled sheet metal and 2 connectors MF - M140/F40

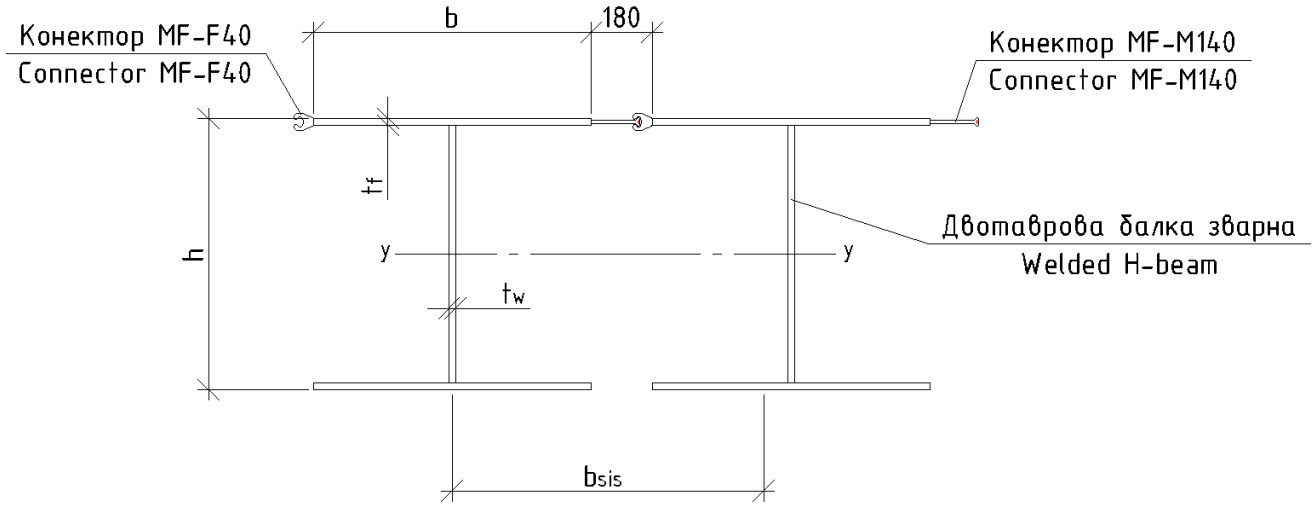


Fig.9.6.3.2 Cross-section of welded H-beam БД3 using rolled sheet metal and one connector MF - M140/F40

Table 9.6.4 a) Data for MF- M90/F90 connectors applying, two-flange connected (Fig. 9.6.4.1)

Characteristics of welded H-beams															Characteristics of welded sections			Combination			
Combination name	**Beam type**	**Depth of a cross section**	**Width of a cross section**	**Web thickness**	**Flange thickness**	**Cross-section area**	**Weight**	**Moment of inertia**	**Section modulus**	**First moment of area**	**Radius of gyration**	**Moment of inertia**	**Section modulus**	**Radius of gyration**	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h.mm	b.mm	t_w mm	$t_{f.}$ mm	A.cm^2	kg/m	Iy. cm^4	Wy. cm^3	Sy. cm^3	iy.mm	Iz. cm^4	Wz. cm^3	iz.mm	cm	Iy, cm^4	Wy. cm^3	bsys.m	G97%	Isys. cm^4	Wsys.cm^3
БДЗ-778х367х20/18-2MF-F90/M90-100н	778х367х18	778,0	367,0	18,0	20,0	279,6	219,5	271206	6972	40,1	311,0	16513	900	77,0	38,90	365950	9407	0,47	528,55	783619	20144
БДЗ-778х419х20/18-2MF-F90/M90-100н	778х419х18	778,0	419,0	18,0	20,0	300,4	235,8	301090	7740	44,0	317,0	24556	1172	90,0	38,90	348462	8958	0,52	507,00	671411	17260
БДЗ-778х491х20/18-2MF-F90/M90-100н	778х491х18	778,0	491,0	18,0	20,0	329,2	258,5	342469	8804	49,5	323,0	39493	1609	110,0	38,90	389841	10022	0,59	483,65	659629	16957
БДЗ-1035х367х22/18-2MF-F90/M90-100н	1035х367х18	1035,0	367,0	18,0	22,0	294,3	231,0	293534	7507	42,9	316,0	18161	990	79,0	51,75	379647	7336	0,47	553,18	812948	15709
БДЗ-1035х367х25/18-2MF-F90/M90-100н	1035х367х18	1035,0	367,0	18,0	25,0	360,8	283,2	611417	11815	68,2	412,0	20644	1125	76,0	51,75	696478	13459	0,47	664,96	1491387	28819
БДЗ-1035х367х25/20-2MF-F90/M90-100н	1035х367х20	1035,0	367,0	20,0	25,0	380,5	298,7	627345	12123	70,6	406,0	20662	1126	74,0	51,75	712406	13766	0,47	698,15	1525494	29478
БДЗ-1035х367х25/22-2MF-F90/M90-100н	1035х367х22	1035,0	367,0	22,0	25,0	400,2	314,2	643273	12430	73,0	401,0	20684	1127	72,0	51,75	728334	14074	0,47	731,34	1559601	30137
БДЗ-1035х419х25/18-2MF-F90/M90-100н	1035х419х18	1035,0	419,0	18,0	25,0	386,8	303,6	677737	13096	74,7	419,0	30698	1465	89,0	51,75	762798	14740	0,52	637,64	1469745	28401
БДЗ-1035х419х25/20-2MF-F90/M90-100н	1035х419х20	1035,0	419,0	20,0	25,0	406,5	319,1	693665	13404	77,2	413,0	30716	1466	87,0	51,75	778726	15048	0,52	667,50	1500435	28994
БДЗ-1035х419х25/22-2MF-F90/M90-100н	1035х419х22	1035,0	419,0	22,0	25,0	426,2	334,6	709593	13712	79,6	408,0	30737	1467	85,0	51,75	794654	15356	0,52	697,37	1531125	29587
БДЗ-1035х491х25/18-2MF-F90/M90-100н	1035х491х18	1035,0	491,0	18,0	25,0	422,8	331,9	769565	14871	83,8	427,0	49369	2011	108,0	51,75	854626	16515	0,59	607,84	1446067	27943
БДЗ-1035х491х25/20-2MF-F90/M90-100н	1035х491х20	1035,0	491,0	20,0	25,0	442,5	347,4	785493	15179	86,2	421,0	49387	2012	106,0	51,75	870554	16822	0,59	634,07	1473018	28464
БДЗ-1035х491х25/22-2MF-F90/M90-100н	1035х491х22	1035,0	491,0	22,0	25,0	462,2	362,8	801421	15486	88,7	416,0	49409	2013	103,0	51,75	886481	17130	0,59	660,13	1499968	28985
БДЗ-1035х738х25/18-2MF-F90/M90-100н	1035х738х18	1035,0	738,0	18,0	25,0	546,3	428,8	1084585	20958	115,0	446,0	167526	4540	175,0	51,75	1169646	22602	0,84	544,31	1395759	26971
БДЗ-1035х738х25/20-2MF-F90/M90-100н	1035х738х20	1035,0	738,0	20,0	25,0	566,0	444,3	1100513	21266	117,4	441,0	167544	4541	172,0	51,75	1185574	22910	0,84	562,81	1414766	27338
БДЗ-1035х738х25/22-2MF-F90/M90-100н	1035х738х22	1035,0	738,0	22,0	25,0	585,7	459,8	1116441	21574	119,9	437,0	167565	4541	169,0	51,75	1201502	23217	0,84	581,31	1433773	27706

Table 9.6.4 b) Data for MF- M90/F90 connectors applying, one-flange connected(Fig. 9.6.4.2)

Characteristics of welded H-beams															Characteristics of welded sections			Combination			
Combination name	**Beam type**	**Depth of a cross section**	**Width of a cross section**	**Web thickness**	**Flange thickness**	**Cross-section area**	**Weight**	**Moment of inertia**	**Section modulus**	**First moment of area**	**Radius of gyration**	**Moment of inertia**	**Section modulus**	**Radius of gyration**	**y**	**Total moment of inertia**	**Section modulus**	Combination width	Weight	Moment of inertia	Section modulus
		h.mm	b.mm	t_w mm	$t_{f.}$ mm	A.cm^2	kg/m	Iy. cm^4	Wy. cm^3	Sy. cm^3	iy.mm	Iz. cm^4	Wz. cm^3	iz.mm	cm	Iy, cm^4	Wy. cm^3	bsys.m	G97%	Isys. cm^4	Wsys.cm^3
БДЗ-778х367х20/18-MF-F90/M90-100н	778х367х18	778,0	367,0	18,0	20,0	279,6	219,5	271206	6972	40,1	311,0	16513	900	77,0	34,77	313189	7278	0,47	528,55	670640	15584
БДЗ-778х419х20/18-MF-F90/M90-100н	778х419х18	778,0	419,0	18,0	20,0	300,4	235,8	301090	7740	44,0	317,0	24556	1172	90,0	35,02	343406	8028	0,52	507,00	661669	15468
БДЗ-778х491х20/18-MF-F90/M90-100н	778х491х18	778,0	491,0	18,0	20,0	329,2	258,5	342469	8804	49,5	323,0	39493	1609	110,0	35,33	385183	9069	0,59	483,65	651748	15346
БДЗ-1035х367х22/18-MF-F90/M90-100н	1035х367х18	1035,0	367,0	18,0	22,0	294,3	231,0	293534	7507	42,9	316,0	18161	990	79,0	46,42	370283	6488	0,47	553,18	792897	13892
БДЗ-1035х367х25/18-MF-F90/M90-100н	1035х367х18	1035,0	367,0	18,0	25,0	360,8	283,2	611417	11815	68,2	412,0	20644	1125	76,0	47,34	688779	12266	0,47	664,96	1474901	26265
БДЗ-1035х367х25/20-MF-F90/M90-100н	1035х367х20	1035,0	367,0	20,0	25,0	380,5	298,7	627345	12123	70,6	406,0	20662	1126	74,0	47,55	705071	12603	0,47	698,15	1509788	26986
БДЗ-1035х367х25/22-MF-F90/M90-100н	1035х367х22	1035,0	367,0	22,0	25,0	400,2	314,2	643273	12430	73,0	401,0	20684	1127	72,0	47,74	721330	12937	0,47	731,34	1544604	27702
БДЗ-1035х419х25/18-MF-F90/M90-100н	1035х419х18	1035,0	419,0	18,0	25,0	386,8	303,6	677737	13096	74,7	419,0	30698	1465	89,0	47,62	755572	13520	0,52	637,64	1455823	26051
БДЗ-1035х419х25/20-MF-F90/M90-100н	1035х419х20	1035,0	419,0	20,0	25,0	406,5	319,1	693665	13404	77,2	413,0	30716	1466	87,0	47,80	771822	13857	0,52	667,50	1487133	26699
БДЗ-1035х419х25/22-MF-F90/M90-100н	1035х419х22	1035,0	419,0	22,0	25,0	426,2	334,6	709593	13712	79,6	408,0	30737	1467	85,0	47,97	788044	14191	0,52	697,37	1518390	27343
БДЗ-1035х491х25/18-MF-F90/M90-100н	1035х491х18	1035,0	491,0	18,0	25,0	422,8	331,9	769565	14871	83,8	427,0	49369	2011	108,0	47,94	847967	15262	0,59	607,84	1434801	25824
БДЗ-1035х491х25/20-MF-F90/M90-100н	1035х491х20	1035,0	491,0	20,0	25,0	442,5	347,4	785493	15179	86,2	421,0	49387	2012	106,0	48,10	864169	15598	0,59	634,07	1462215	26392
БДЗ-1035х491х25/22-MF-F90/M90-100н	1035х491х22	1035,0	491,0	22,0	25,0	462,2	362,8	801421	15486	88,7	416,0	49409	2013	103,0	48,24	880350	15931	0,59	660,13	1489593	26957
БДЗ-1035х738х25/18-MF-F90/M90-100н	1035х738х18	1035,0	738,0	18,0	25,0	546,3	428,8	1084585	20958	115,0	446,0	167526	4540	175,0	48,75	1164400	21267	0,84	544,31	1389499	25378
БДЗ-1035х738х25/20-MF-F90/M90-100н	1035х738х20	1035,0	738,0	20,0	25,0	566,0	444,3	1100513	21266	117,4	441,0	167544	4541	172,0	48,85	1180499	21600	0,84	562,81	1408711	25775
БДЗ-1035х738х25/22-MF-F90/M90-100н	1035х738х22	1035,0	738,0	22,0	25,0	585,7	459,8	1116441	21574	119,9	437,0	167565	4541	169,0	48,94	1196588	21931	0,84	581,31	1427909	26171

Note: Symbols for beams: БДЗ-778×367×20/18-MF(or 2 MF)- F90/M90-100н

Where:БДЗ – is a beam type – the H-beam , welded;

778– beam height in mm; 367– beam width in mm; 20/18 –flange and web thickness,

MF or 2 MF - the number of sets of connectors per one beam, installed in one or two of its decks accordingly;

F90/M90 – the connector type used.

With this, 100 — distance between connected beams, н - type of welding a beam to a connector (overlap).

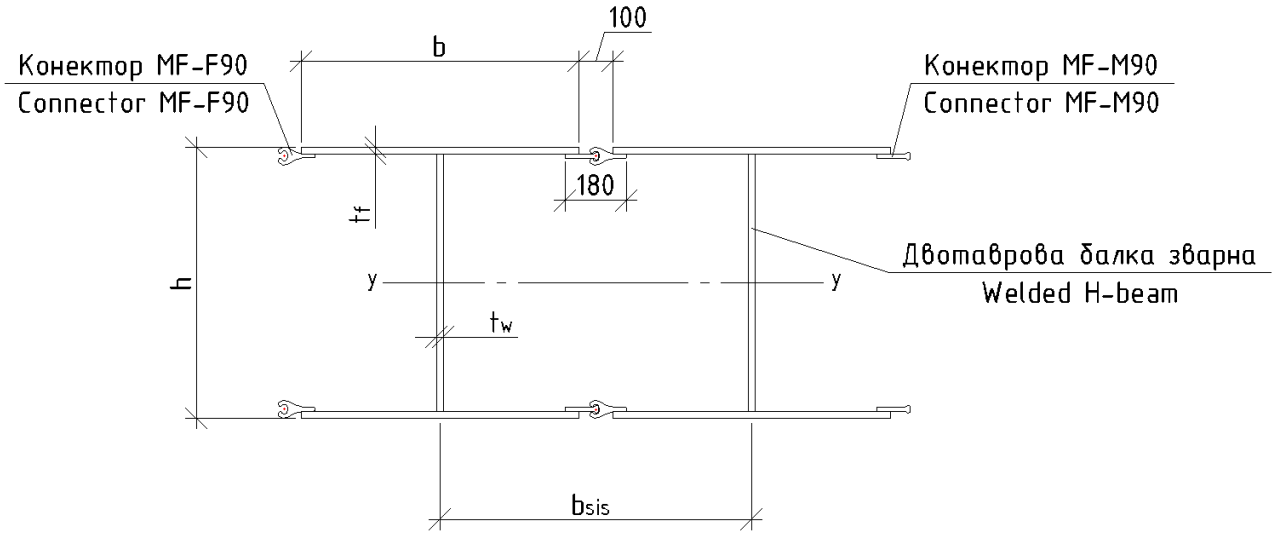


Fig.9.6.4.1 Cross-section of welded H-beam БДЗ using rolled sheet metal and 2 MF - M90/F90 connectors sets

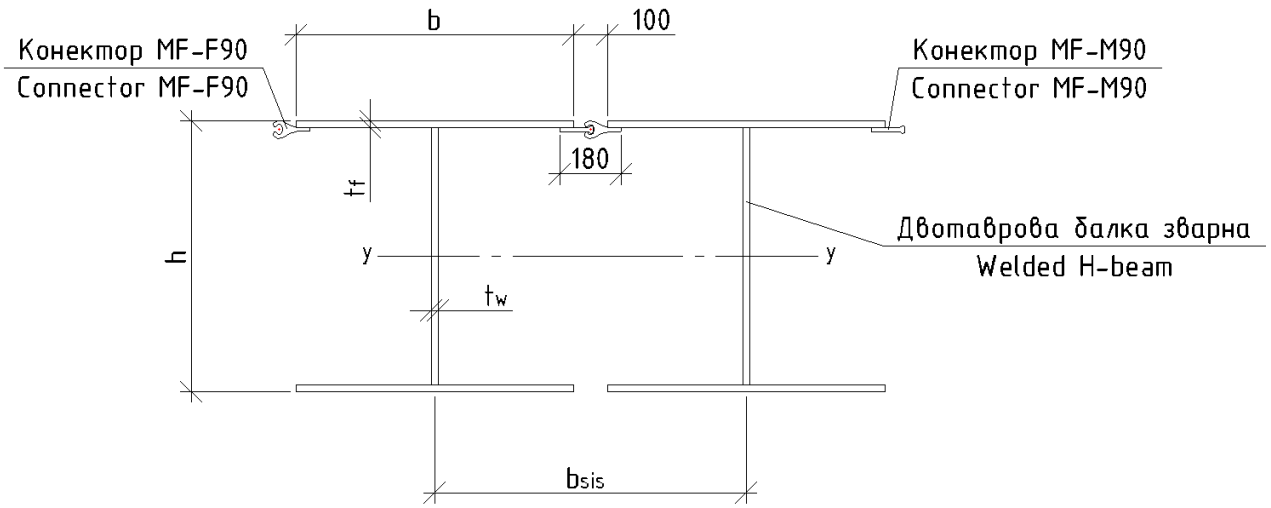


Fig.9.6.4.2 Cross-section of welded H-beam БДЗ using rolled sheet metal and one MF - M90/F90 connectors set

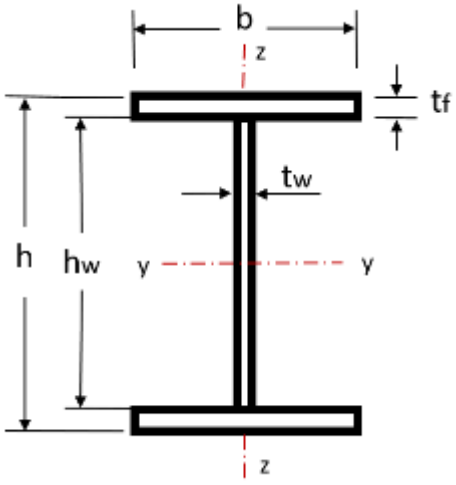
9.7 Attachment 7. An example of section grade determination in compliance with the Eurucode 3 (ДСТУ-Н.Б EN 1993-1-1).

During the verification calculation of the cross-section of each bearing element of the frame, it should be classified depending on the level of normal stresses, the cross-section geometric dimensions and physical and mechanical characteristics of the materials. The purpose of the classification is to determine limit, upon reaching which, the bearing capacity of the cross section is calculated considering the local stability loss.

The cross-sections classification depends on the ratio of width to thickness of sections of the cross-section located in its compressed area. Different compressed cross-sectional areas, such as a wall or a flange, can belong to different grades. The cross-section is classified according to the highest (least favorable) grade of its compressed areas. The limiting width-to-thickness ratios of compressed cross-sectional areas for grades 1, 2 and 3 are given in the Table 5.2 of the Standard ДСТУ-Н.Б EN 1993-1-1. Cross-sectional areas that do not belong to class 3, belong to class 4.

Bending test of the beam cross-section.

It is necessary to calculate the resistance to the bending moment taking into account the full lateral separation. The characteristics of the section are given below.



Initial data:

Cross-section height	$h := 800\ mm$
Cross-section width	$b := 500\ mm$
Flange thickness	$t_f := 34\ mm$
Web thickness	$t_w := 22\ mm$
Web height	$h_w := h - 2 \cdot t_f = 732\ mm$

We use S355 steel as a structural material of the beam. With a nominal steel thickness of 16 mm < t < 40 mm, the nominal yield strength for the selected steel in accordance with the Standard ДСТУ EN 10025-2, is $f_y = 345 \frac{N}{mm^2}$, and $E = 210000 \frac{N}{mm^2}$ is a modulus of elasticity.

Area of the beam cross-section is:

$$A := h_w \cdot t_w + 2 \cdot b \cdot t_f = 501\ cm^2$$

Cross-section moment of inertia relative to the y-y axis is:

$$I_y := \frac{t_w \cdot h_w^{\ 3}}{12} + \frac{b \cdot t_f^{\ 3}}{12} + 2\ t_f \cdot b \cdot \left(\frac{h_w}{2} + \frac{t_f}{2}\right)^2 = 570814\ cm^4$$

Cross-section moment of inertia relative to the z-z axis is:

$$I_z := \frac{h_w \cdot t_w^{\,3}}{12} + \frac{2 \cdot t_f \cdot b^3}{12} = 70898\ cm^4$$

Section modulus of the beam cross-section relative to the y-y axis is:

$$W_{el.y} := I_y \cdot \frac{2}{h} = 14270\ cm^3$$

Section modulus of the beam cross-section relative to the z-z axis is:

$$W_{el.z} := I_z \cdot \frac{2}{b} = 2836\ cm^3$$

For steel H-beam profiles, section modulus taking into account the coefficient of limited plastic deformations development is:

$$W_{pl.y} := b \cdot t_f \cdot (h - t_f) + 0.25\ t_w \cdot (h - 2 \cdot t_f)^2 = 15969\ cm^3$$

$$W_{pl.z} := 2 \cdot \left(t_f \cdot \left(\frac{b}{2}\right)^2 + (h - 2 \cdot t_f) \cdot \left(\frac{t_w}{2}\right)^2 \right) = 4427\ cm^3$$

Radius of inertia relative to the corresponding axis is:

$$i_y := \sqrt{\frac{I_y}{A}} = 34\ cm \qquad i_z := \sqrt{\frac{I_z}{A}} = 12\ cm$$

Is:

Cross-section classification (the Standard ДСТУ-Н.Б EN 1993-1-1, paragraph.5.5.2)

To determine the class of the section, we find the coefficient

$$\varepsilon := \sqrt{\frac{235\ MPa}{f_y}} = 0.825$$

For the web (Table 5.2, page 1)

The maximum width-to-thickness ratio of the web for the 1st cross-section grade:

the minimum leg of a flange weld

$$k_f := 16\ mm$$

$$c_w := h_w - 2 \cdot k_f = 700\ mm$$

$$\frac{c_w}{t_w} \le 72 \cdot \varepsilon$$

$$\frac{c_w}{t_w} = 32$$

$$72 \cdot \varepsilon = 59 \quad 32 < 59$$

the condition is satisfied

Therefore, under the bending action, the web belongs to the 1st grade

For the flange (Table 5.2, page 2)

The maximum width-to-thickness ratio of the flange for the 1st cross-section grade:

$$c_f := \frac{\left(b - t_w - 2\ k_f\right)}{2} = 223\ mm$$

$$\frac{c_f}{t_f} = 6.56$$

$$9 \cdot \varepsilon = 7.43$$

the condition is satified

In the cross-section of the beam, the flange belongs to the 1st grade.

Thus, the cross-section of the beam under the bending action belongs to the 1st cross-section grade.

Design bending resistance relative to the y-y axis of the cross-section is:

$$M_{c_Rd} = \frac{f_y \cdot W_{pl.y}}{\gamma_{M0}} = 5509kNm \qquad M_{c_Rd} = \frac{f_y \cdot W_{el.y}}{\gamma_{M0}} = 4923kNm$$

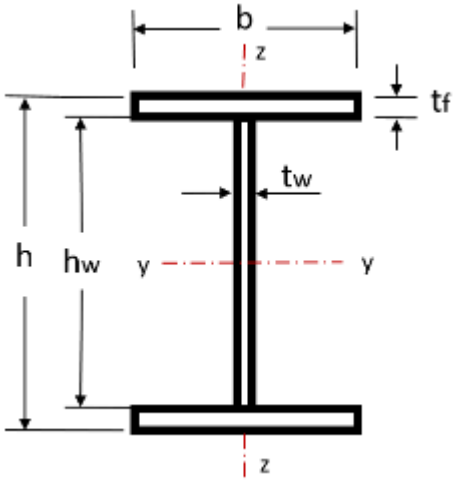
$\gamma_{M0=1}$ - partial resistance coefficient of cross-sections regardless of the grade

Design bending resistance relative to the z-z axis of the cross-section

$$M_{c_Rd} = \frac{f_y \cdot W_{pl.z}}{\gamma_{M0}} = 1527kN \cdot m \qquad M_{c_Rd} = \frac{f_y \cdot W_{el.z}}{\gamma_{M0}} = 978kN \cdot m$$

Compression test of the beam cross-section

It is necessary to calculate the compressive resistance.



Initial data:

Cross-section height	$h := 800\ mm$
Cross-section width	$b := 500\ mm$
Flange thickness	$t_f := 34\ mm$
Web thickness	$t_w := 22\ mm$
Web height	$h_w := h - 2 \cdot t_f = 732\ mm$

We use S355 steel as a structural material of the beam. With a nominal steel thickness of 16 mm< t < 40 mm, the nominal yield strength for the selected steel in accordance with the Standard ДСТУ EN 10025 is $f_y = 345 \frac{N}{mm^2}$, and $E = 210000 \frac{N}{mm^2}$ - modulus of elasticity.

Area of the beam cross-section:

$$A := h_w \cdot t_w + 2 \cdot b \cdot t_f = 501\ cm^2$$

Cross-section moment of inertia relative to the y-y axis is:

$$I_y := \frac{t_w \cdot h_w^{\,3}}{12} + \frac{b \cdot t_f^{\,3}}{12} + 2\ t_f \cdot b \cdot \left(\frac{h_w}{2} + \frac{t_f}{2}\right)^2 = 570814\ cm^4$$

Cross-section moment of inertia relative to the z-z axis is:

$$I_z := \frac{h_w \cdot t_w^{\,3}}{12} + \frac{2 \cdot t_f \cdot b^3}{12} = 70898\ cm^4$$

Section modulus of the beam cross-section relative to the y-y axis is:

$$W_{el.y} := I_y \cdot \frac{2}{h} = 14270\ cm^3$$

Section modulus of the beam cross-section relative to the z-z axis is:

$$W_{el.z} := I_z \cdot \frac{2}{b} = 2836\ cm^3$$

For steel H-beam profiles section modulus of the cross-section taking into account the coefficient of limited plastic deformations development is:

$$W_{pl.y} := b \cdot t_f \cdot (h - t_f) + 0.25\ t_w \cdot (h - 2 \cdot t_f)^2 = 15969\ cm^3$$

$$W_{pl.z} := 2 \cdot \left(t_f \cdot \left(\frac{b}{2}\right)^2 + (h - 2 \cdot t_f) \cdot \left(\frac{t_w}{2}\right)^2\right) = 4427\ cm^3$$

Radius of inertia relative to the corresponding axis is:

$$i_y := \sqrt{\frac{I_y}{A}} = 34\ cm \qquad i_z := \sqrt{\frac{I_z}{A}} = 12\ cm$$

Cross-section classification (the Standard ДСТУ-Н.Б EN 1993-1-1, paragraph 5.5.2)

To determine the class of the section, we find the coefficient

$$\varepsilon := \sqrt{\frac{235\ MPa}{f_y}} = 0.825$$

For the web

The maximum ratio of width and wall thickness for the 1st cross-section grade:

the minimum leg of the chord weld

$$k_f := 16\ mm$$

$$c_w := h_w - 2 \cdot k_f = 700\ mm$$

$$\frac{c_w}{t_w} \le 33 \cdot \varepsilon$$

$$\frac{c_w}{t_w} = 31.8$$

$$33 \cdot \varepsilon = 27$$

$$31.8 > 27$$

the condition is not satisfied

The maximum width-to-thickness ratio of the web of the 2nd cross-section grade:

$$\frac{c_w}{t_w} \le 38 \cdot \varepsilon$$

$$\frac{c_w}{t_w} = 32$$

$$38 \cdot \varepsilon = 31$$

$$32 > 31$$

the condition is not satisfied

The maximum width-to-thickness ratio of the web of the 3rd section class:

$$\frac{c_w}{t_w} \le 42 \cdot \varepsilon$$

$$\frac{c_w}{t_w} = 31.82$$

$$42 \cdot \varepsilon = 35$$

$$31.82 < 35$$

the condition is satisfied

Under the compression action, the web belongs to the 3rd grade.

For the flange

$$c_f := \frac{\left(b - t_w - 2\ k_f\right)}{2} = 223\ mm$$

The maximum width-to-thickness ratio of the flange for the 1st cross-section grade

$$\frac{c}{t_f} \leq 9 \cdot \varepsilon$$

$$\frac{c_f}{t_f} = 6.559$$

$$9 \cdot \varepsilon = 7.428$$

$$6.559 < 7.428$$

the condition is satisfied

In the beam cross-section, the flange belongs to the 1st grade.

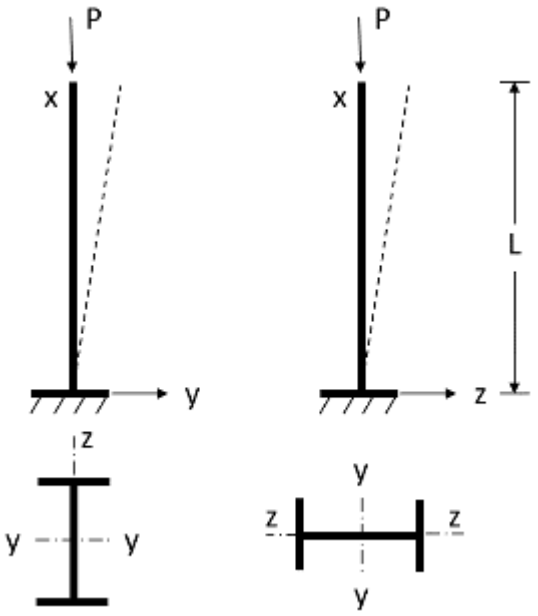
Thus, the beam cross-section under the compression action belongs to the 3rd cross-section grade.

For sections of the 1st , 2nd and 3rd grades, the design compressive strength according to the paragraph 6.2.4 of the Standard ДСТУ-Н.Б EN 1993-1-1 is determined as:

$$N_{c_Rd} := \frac{f_y \cdot A}{\gamma_{M0}}$$

$$N_{c_{Rd}} = 172689kN$$

Resistance test to stability loss of the cross-section elements according to the bending shape (the Standard ДСТУ-Н.Б EN 1993-1-1)



$N_{ed} = 5000kN$ design compression

$L := 7.50\ m$

$L_{cr} = 2 \cdot L = 15m$ equivalent length in the considered bending plane

Radius of inertia relative to the corresponding axis is:

$$i_y = \sqrt{\frac{I_y}{A}} = 34cm$$

$$i_y = \sqrt{\frac{I_z}{A}} = 12cm$$

conventional flexibility in XOY plane

$$\bar{\lambda}_y := \frac{L_{cr}}{i_z} \cdot \frac{1}{93.9 \cdot \varepsilon} = 1.63$$

conventional flexibility in XOZ plane

$$\bar{\lambda}_y := \frac{L_{cr}}{i_z} \cdot \frac{1}{93.9 \cdot \varepsilon} = 1.63$$

α - imperfection factor for stability loss curves (the Standard ДСТУ-Н.Б EN 1993-1-1, Tables 6.1, 6.2)

$$\alpha_y := 0.34$$

$$\alpha_z := 0.49$$

$$\Phi_y := 0.5 \cdot \left(1 + \alpha_y \cdot \left(\bar{\lambda}_y - 0.2\right) + \bar{\lambda}_y^{\,2}\right) = 2.07$$

$$\Phi_z := 0.5 \cdot \left(1 + \alpha_z \cdot \left(\bar{\lambda}_z - 0.2\right) + \bar{\lambda}_z^{\,2}\right) = 0.76$$

Reduction factor for the corresponding form of stabilityf loss is:

$$\chi_y := \frac{1}{\Phi_y + \sqrt{\Phi_y^{\,2} - \bar{\lambda}_y^{\,2}}} = 0.3 \qquad \chi_z := \frac{1}{\Phi_z + \sqrt{\Phi_z^{\,2} - \bar{\lambda}_z^{\,2}}} = 0.8$$

we take

$$\chi_{min} := 0.3$$

The design resistance to stability loss of of the compressed element is accepted as follows:

$$N_{b_Rdy} := \frac{\chi_{min} \cdot A \cdot f_y}{\gamma_{M1}} = 5186\ kN \qquad N_{b_Rdz} := \frac{\chi_z \cdot A \cdot f_y}{\gamma_{M1}} = 13846\ kN$$

$$\gamma_{M1} \equiv 1$$

$$\frac{N_{ed}}{N_{b_Rdz}} = 0.36$$

$$\frac{N_{ed}}{N_{b_RDy}} = 096 < 1$$

the condition is satisfied

9.8 Attachment 8. Sequence of the elements calculation according to the Standard ДСТУ НБ. EN 1993-1-1

Compressed-bending and eccentric-compressed elements

Item	Step	Reference to the Standard ДСТУ НБ. EN 1993-1-1
1	Determine $N_{b,y,Rd}$ і $N\ b_{,z,Rd}$ (see 2)	6.3.1.1(3)
2	Determine $M_{b,Rd}$ (see 4)	6.3.2
3	Determine $M_{cb,z\ ,Rd}$ (see Note)	6.2.5
4	Determine C_{my} , C_{mz} та C_{mLT} depending on the shape of the bending moments epure	Table B.3
5	Based on the type and grade of cross-section, select the appropriate curves for determining the interaction coefficients k	
6	Determine coefficients k for $\bar{\lambda}$ and $N_{Ed}\ /\ N_{b,Rd}$ according to the corresponding curves	Table B.1 or Table B.2
7	Make a test for the joint bending action with respect to two axes and stability loss of in the form of longitudinal in-plane bending according to the formula: $\frac{N_{Ed}}{N_{b,y,Rd}} + k_{yy}\frac{M_{y,Ed}}{M_{b,Rd}} + k_{yz}\frac{M_{z,Ed}}{M_{c,b,zRd}} \leq 1$ If the condition is not satisfied, choose a stronger section, or reduce the design length by constructive measures	6.3.3(4)
8	Make a test for the joint bending action with respect to two axes and stability loss in the form of longitudinal out-of- plane bending according to the formula: $\frac{N_{Ed}}{N_{b,z,Ed}} + k_{zy}\frac{M_{y,Ed}}{M_{b,Rd}} + k_{zz}\frac{M_{z,Ed}}{M_{c,b,z,Rd}} \leq 1$ If the condition is not satisfied, choose a stronger section, or reduce the design length by constructive measures	6.3.3(4)

Note :

$M_{cb,z,Rd}$ is calculated according to the formula $M_{cb,z,Rd} = \frac{f_y W_z}{\gamma_{M1}}$, which is equivalent to the expression for the bearing capacity for out-of-plane bending according to the paragraph 6.2.5 in case, when $\gamma_{M1} = \gamma_{M0}$

Centric-compressed elements

Item	Step	Reference to the Standard ДСТУ НБ. EN 1993-1-1
1	For the boundary state of the bearing capacity, determine the design force N_{Ed} taking into account the relevant loads and private coefficients	6.4.3 of the Stamdard ДСТУ-НБ EN 1990 and Article 5 of the Standard ДСТУ-НБ EN 1993-1-1
2	Accept a steel grade	
3	Accept preliminary cross-section dimensions and check thickness requirements for selected material. In the first approximation, the area of cross-section can be taken to satisfy the requirement $N_{Ed}/A < f_y$	
4	Determine the cross-section grade. For the 4th cross-section grade, proceed according to the Standard ДСТУ-Н Б EN 1993-1-5 or increase thickness of the cross-section parts, or change the conditions of their attachment	Table 5.2
5	Determine the design length L_{cr} for each of the axes	
6	Define conventional flexibility $\bar{л}$ relative to each of the axes	6.3.1.3(1)
7	Determine the corresponding stability loss curve for each axis depending on the cross-section type and steel thickness	Table 6.2
8	For each axis, determine the reduction factor for longitudinal bending χ and take the smaller one	6.3.1.2. Fig. 4.4
9	Calculate the bearing capacity by stability N_{b,Nb,R_d}. If $N_{b,Rd} > N_{Ed}$, the intersection meets the requirements. If the condition is not satisfied, a stronger section should be chosen or the design length should be reduced by constructive measures.	6.3.1.1(3)
10	Determine the required subgrade of steel	2.3 ДСТУ-НБ EN 1993-1-10

Tensile elements

Item	**Step**	**Reference to the Standard ДСТУ НБ. EN 1993-1-1**
1	For the boundary state according to the bearing capacity, determine the design tensile forces N_{Ed} taking into account the relevant loads and private coefficients г_F	6.4.3 of the Standard ДСТУ-НБ EN 1990 and Article 5 of the Standard ДСТУ-НБ EN 1993-1-1
2	Accept a steel grade	
3	Accept the preliminary cross-section dimensions and check the thickness requirements for the selected material. In the first approximation, the area of the cross-section is taken to satisfy the requirement: $N_{Ed}/A < f_y$	
4	Determine the tensile load-bearing capacity $N_{t\,Nt,Rd}$. For sections with holes $N_{t,Rd}$ should decrease, taking the smaller of the values N_{plR_d}, or $N_{u\,Rd}$. For sections without holes $N_{t,Rd}$ = $N_{pl,Rd}$	6.2.3
5	If $N_{Ed}/N_{t,Rd} \leq 1.0$, the intersection meets the requirements	6.2.3(1)
6	Determine the required subgrade of steel	2.3 of the Standard ДСТУ-НБ EN 1993-1-10

Hinged hot-rolled beams of H-beam section.

Item	Step	Reference to the Standard ДСТУ НБ. EN 1993-1-1
	Determine the support conditions and places of compressed chord bracing from the bending plane	
2	For the boundary state according to the bearing capacity, determine the maximum design shearing force V_{Ed} and the moment M_{Ed} taking into account the relevant loads and private coefficients $г_F$	6.4.3 of the Standard ДСТУ-Н Б EN 1990 and Article 5 of the Standard ДСТУ-Н Б EN 1993-1-1
3	Accept the previous cross-section dimensions and steel пкфвц	
4	Determine the cross-section grade under bending	Table 5.2
5	Determine the bearing capacity of the cross-section for bending and check compliance with the inequality $M_{Ed} \leq M_{c,Rd}$	6.2.5
6	Determine the bearing capacity of the cross-section for shear $V_{pl,Rd}$	6.2.6
7	f $V_{Ed} > V_{pl,Rd}$, then choose a stronger section (with a greater web thickness)	
8	If $V_{Ed} > 0.5Vp_{l,Rd}$, determine the reduced bearing capacity of the section for bending $Mv_{,y,Rd}$ taking into account shear and check if the condition $M_{ed} \leq M_{v,y,Rd}$ satisfied.	6.2.8
9	Check whether the loss of local shear strength is excluded	6.2.6(6)
10	If a loss of local shear strength is not excluded, it is necessary to provide transverse stiffeners and check the strength of the compartment web	Article 5 of the Standard ДСТУ-Н Б EN 1993-1-5
11	If $M_{Ed} > M_{f,Rd}$ i $V_{Ed}/V_{bw,Rd}$ >0.5 check the loss of local strength from the joint action of moment and shearing force	Article 7 of the Standard ДСТУ-Н Б EN 1993-1-5
12	Determine if it is necessary to check the stability of the bending flat shape. If the check is not required (for example, when the compressed chord is completely braced), go to the Item (17)	6.3.2.1(2)
13	Calculation of conventional flexibility $\bar{л}_{LT}$	6.3.2.2
14	If $\bar{л}_{LT} \leq 0.4$, go to the Item (17)	6.3.2.2(4)
15	Calculate the *h/b* ratio and determine $ч_{LT}$, based on $\bar{л}_{LT}$	6.3.2.2, Fig. 6.4
16	etermine the bearing capacity of stability $M_{b,Rd}$ of a member part between the bracing points from the bending plane. If the condition $M_{b,Rd} > M_{Ed}$ is satisfied , then the cross-section meets the requirements. If the condition is not satisfied, you should choose a stronger section or increase the number of bracing elements from the plane.	6.3.2.1
	Repeat the calculation according to the Items 9 to 16 for other areas between bracing elements.	
17	Using the characteristic loads combinations, determine the maximum vertical displacements	6.5.3 Standard ДСТУ-Н Б EN 1990
18	Check whether the vertical movements meet the requirements	Attachment A1 and НБ.2.10. of the Standard ДСТУ-Н Б EN 1990
19	If necessary, a dynamic calculation should be done	
20	Determine the required subgrade of steel	2.3 of the Standard ДСТУ-Н Б EN 1993-1-10
	If $V_{Ed} > 0.5Vp_{l,Rd}$ determine the reduced bearing capacity of the cross-section for bending $Mv_{,y,Rd}$ taking into account shear and check if the condition $M_{ed} \leq M_{v,y,Rd}$ is satisfied	

NOTATIONS USED.

Dimensions

b width of a cross section

h depth of a cross section

d depth of straight portion of a web

t_w web thickness

t_f flange thickness

Properties of materials

f_y yield strength

f_u ultimate strength

E modulus of elasticity

G shear modulus

ν Poisson's ratio in elastic stage

ε coefficient depending on *fy*

Geometric characteristics of sections

A_{eff} reduction factor for the corresponding stability loss curve

A_w area of a web

A_f area of the tension flange

I second moment of area (inertia moment)

W_{pl} plastic section modulus

$W_{el,min}$ minimum elastic section modulus

$W_{eff,min}$ minimum effective section modulus

i – radius of gyration about the relevant axis, determined using the properties of the gross cross-section

Characteristics of elements

$\bar{\lambda}$ Poisson's ratio in elastic stage

$\bar{\lambda}_{LT}$ non dimensional strength for lateral torsional bending

χ reduction factor for relevant bending mode

χ_{LT} reduction factor for lateral-torsional bending

N_{cr} elastic critical force for the relevant bending mode based on the gross cross sectional properties

M_{cr} elastic critical moment for lateral-torsional bending

Loads and impacts

N_{Ed} design normal force

M_{Ed} design bending moment

$M_{y,Ed}$ design bending moment, y-y axis

$M_{z,Ed}$ design bending moment, z-z axis

V_{Ed} design shear force

L_c length between lateral restraints

Bearing capacity of cross-sections, members and connections

Notation for the common case of the cross-section bearing capacity

$N_{t,Rd}$ design values of the resistance to tension force

$N_{pl,Rd}$ design plastic resistance to normal forces of the gross cross-section

$N_{u,Rd}$ design value of resistance to axial force of the net cross-section at holes for fasteners

$N_{c,Rd}$ design resistance to normal forces of the cross-section for uniform compression

$M_{c,Rd}$ design resistance to bending about one principal axis of a cross-section

(appropriate but $M_{c,y,Rd}$; $M_{c,z,Rd}$)

$V_{c,Rd}$ design shear resistance

$V_{pl,Rd}$ design plastic shear resistance

Designation for the bearing capacity of elements

$M_{b,Rd}$ design buckling resistance moment

Utilization factors

α_{cr} factor by which the design loads would have to be increased to cause elastic instability in a global mode

Partial safety factors for bearing capacity

γ_{M0} partial factor for resistance of cross-sections whatever the class is

γ_{M1} partial factor for resistance of members to instability assessed by member checks

γ_{M2} partial factor for resistance of cross-sections in tension to fracture

9.9 Attachment 9. Variants of fixing anchors.

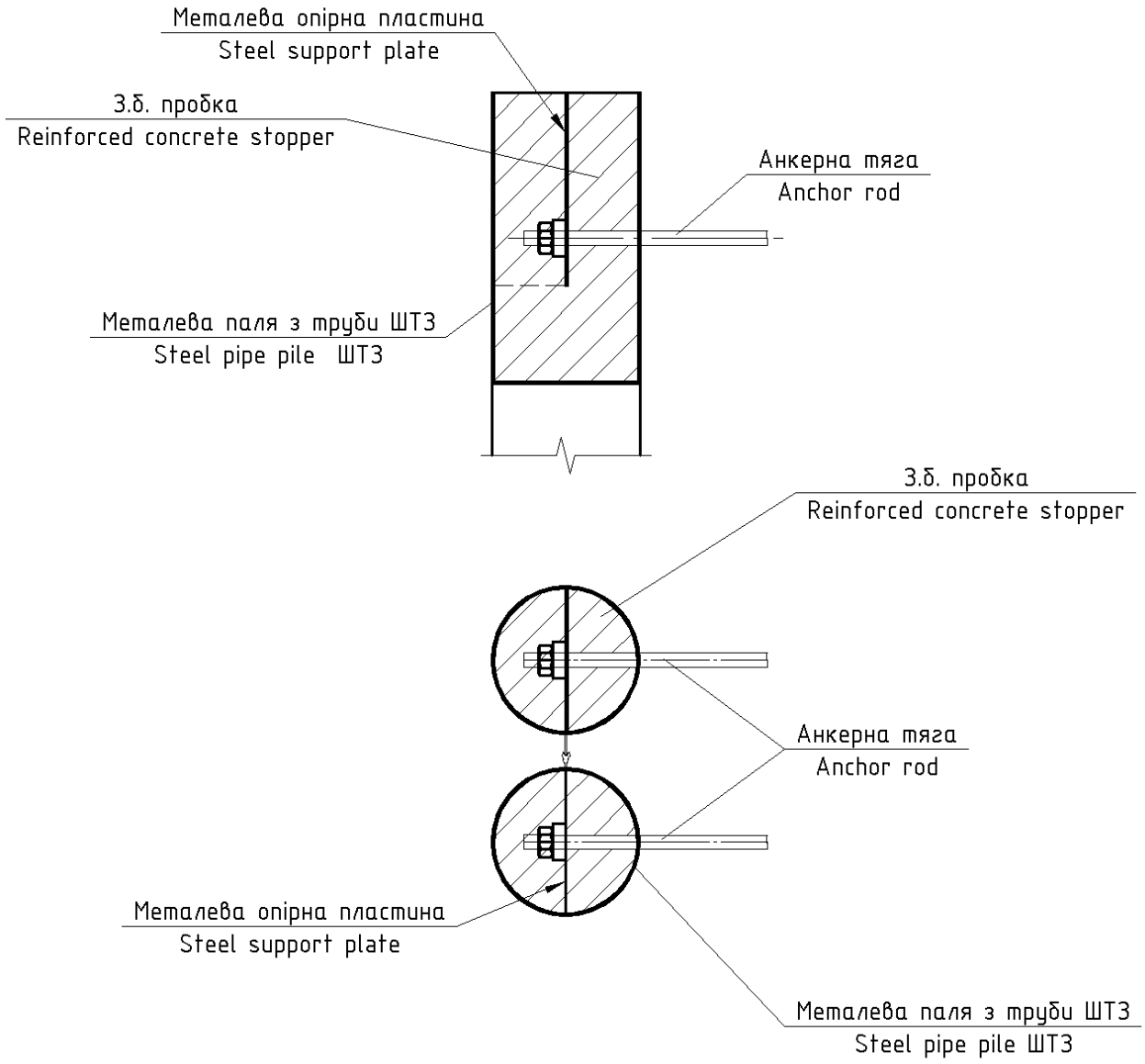


Fig. 9.9.1 Scheme of the anchor rods attachment using support plates.

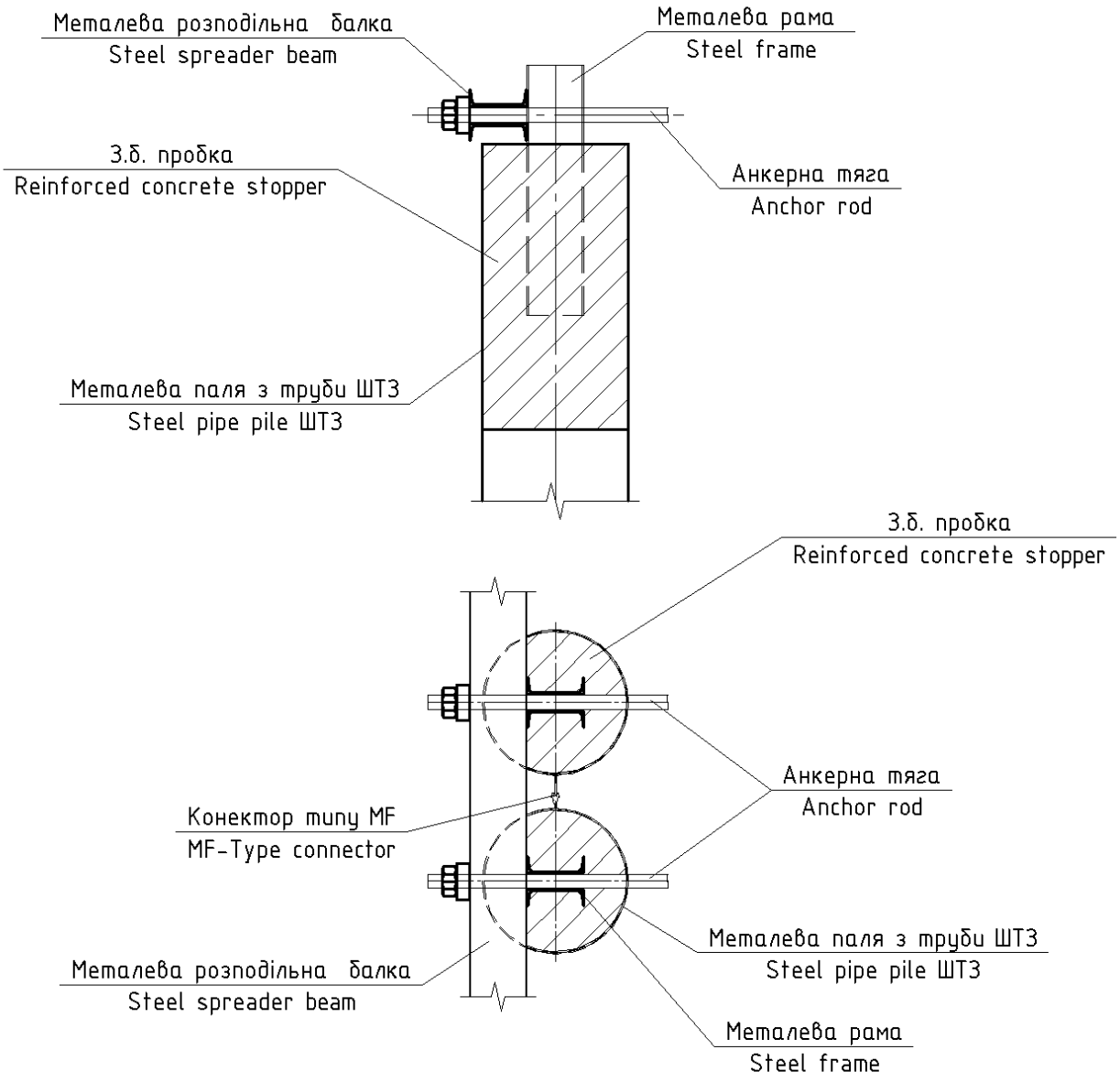


Fig. 9.9.2 Scheme anchor rods attachment applying spreader beams and metal frames

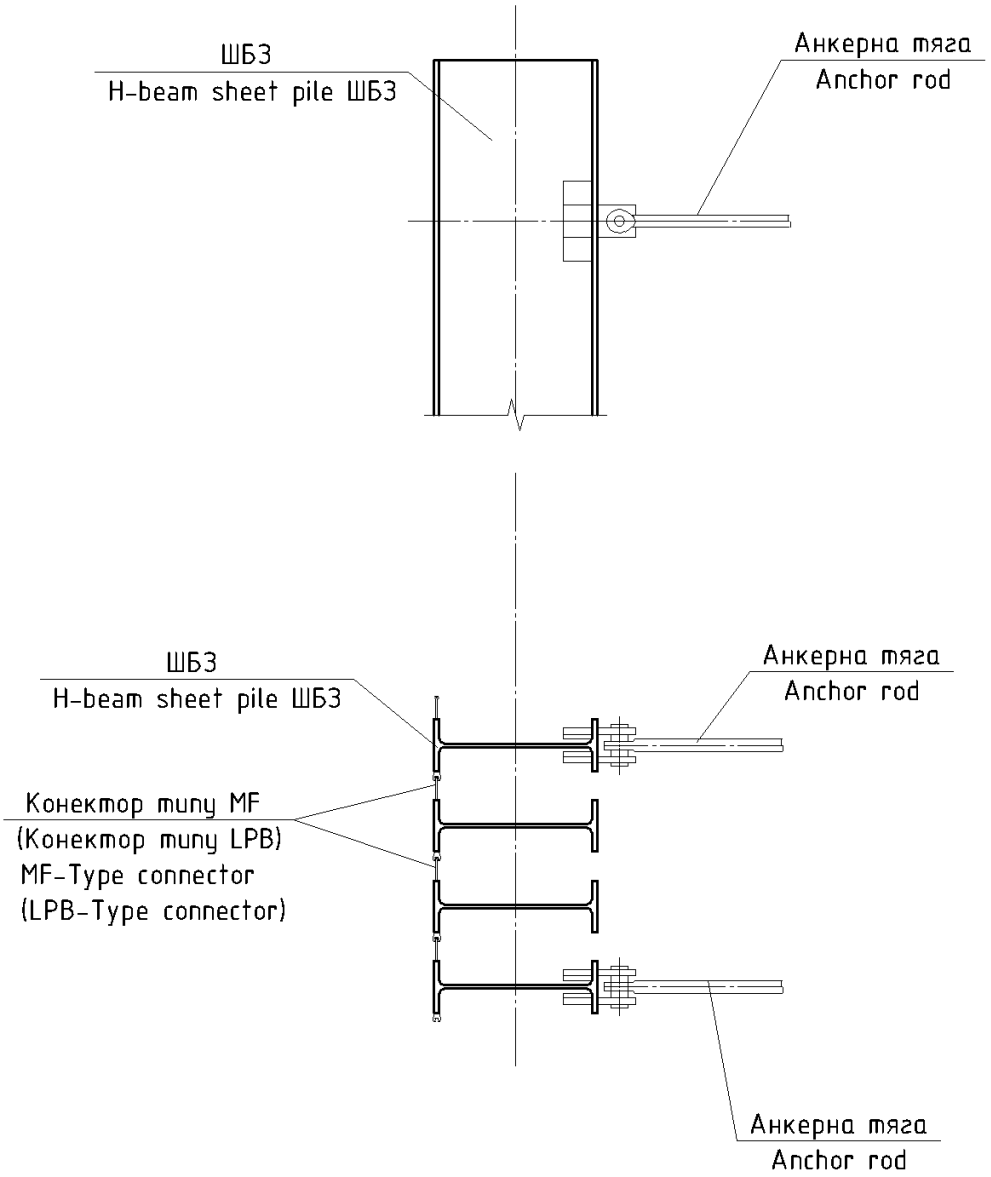


Fig. 9.9.3 Scheme of the anchor rods attachment to the H-beams ШБ3

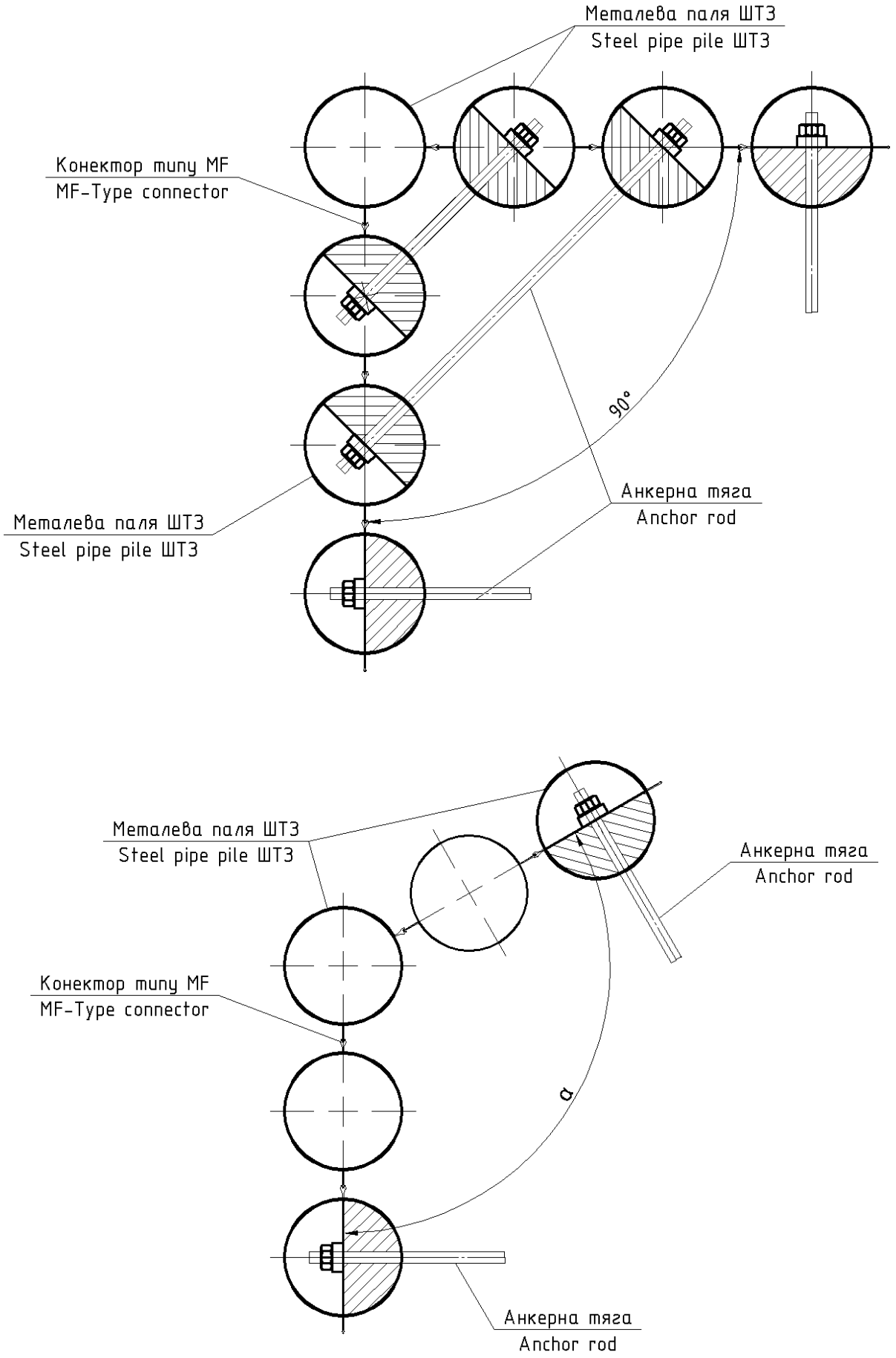


Fig. 9.9.4 Examples of ШТЗ anchorage at different angles of the wall rotation

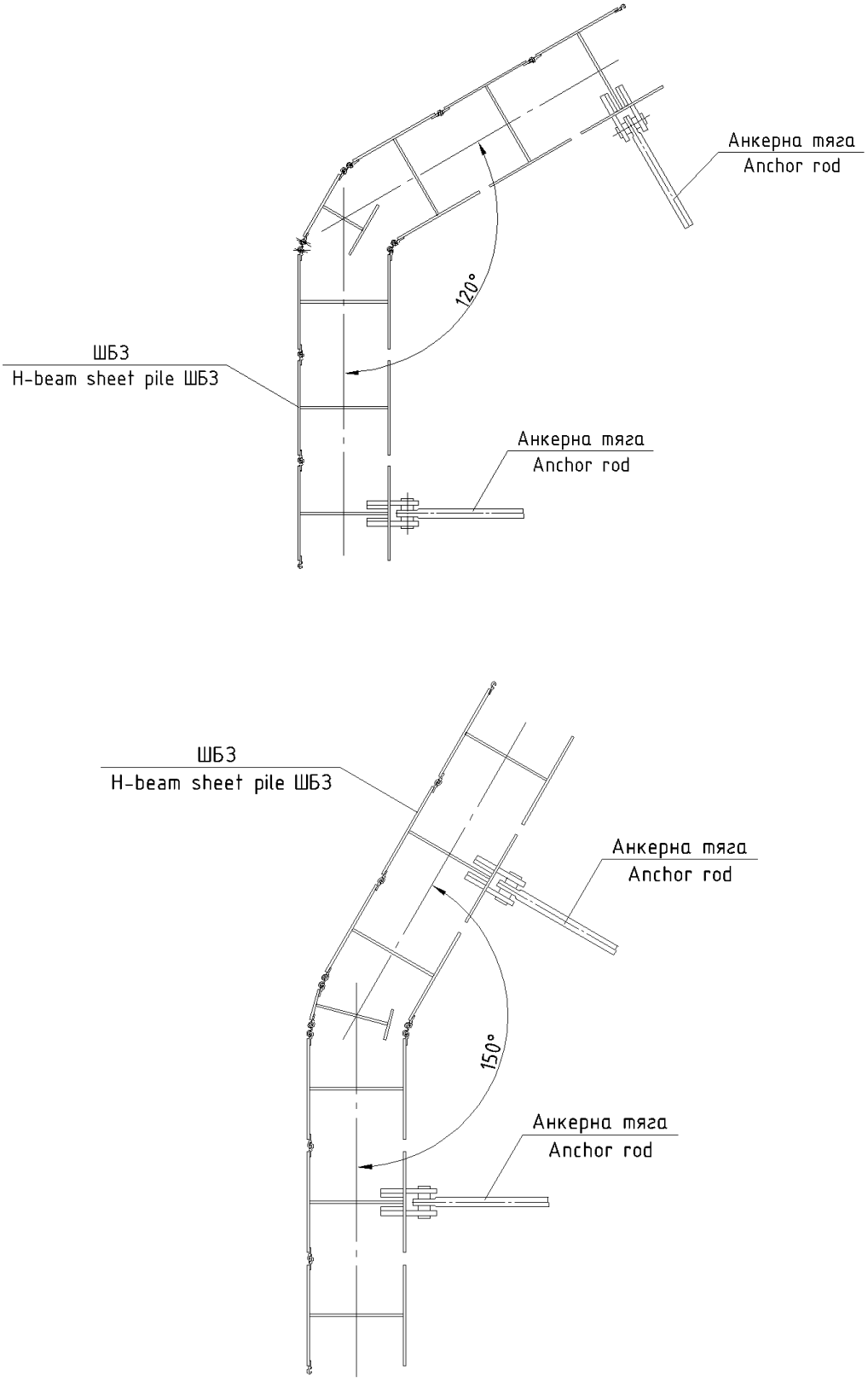


Fig. 9.9.5 Examples of ШБЗ anchorage at different angles of the wall rotation

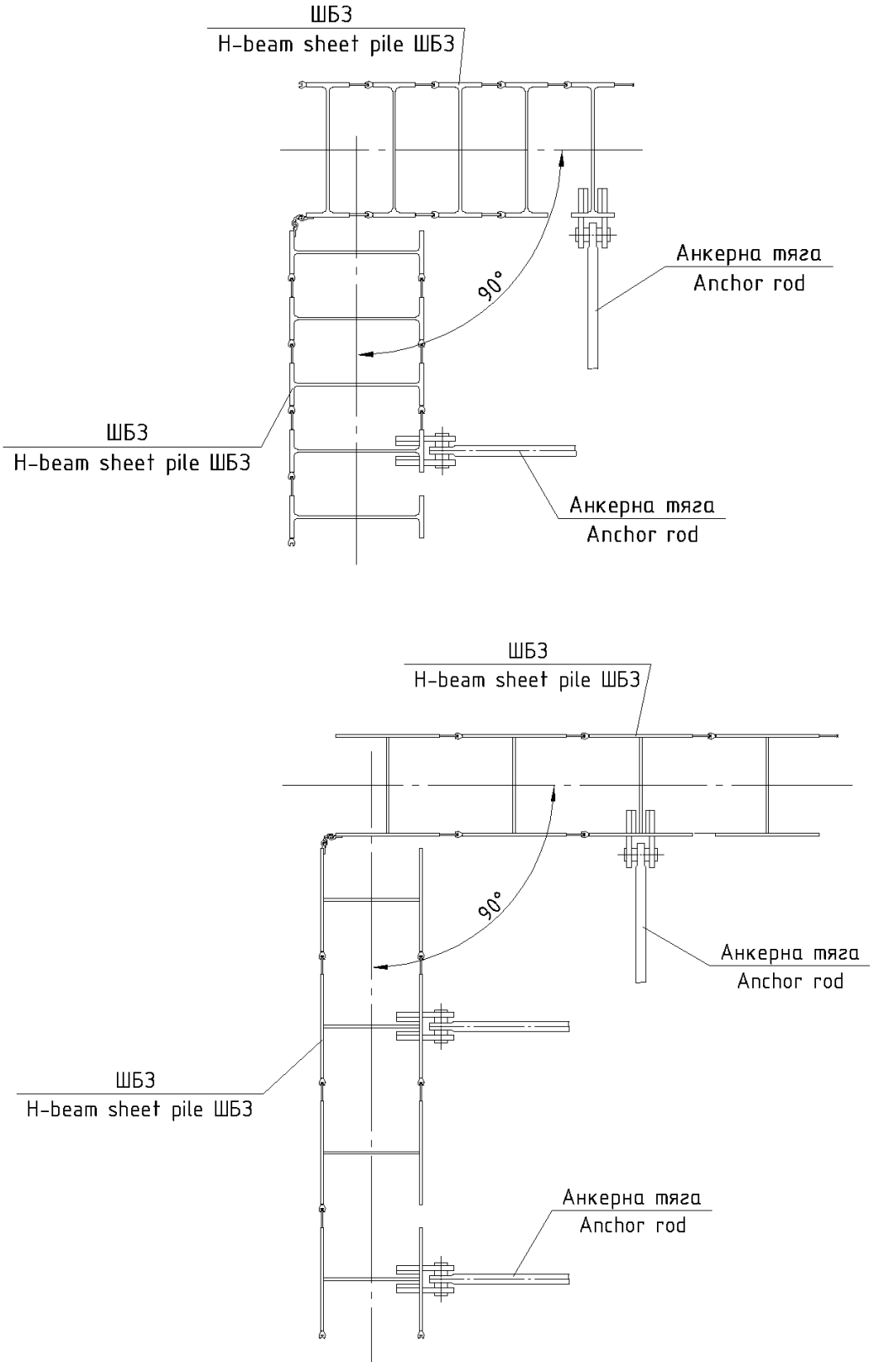


Fig. 9.9.6 Examples of ШБЗ anchorage at 90° angle of the wall rotation