PART 1
STRUCTURAL ANALYSIS OF FLAT WAGONS

1.1 Structural analysis of flat wagons for carrying containers

The flat wagon is designed for carrying freight that does not require protection against atmospheric agents. At present wagon manufacturers produce a great variety of flat wagons using different processing technologies. Consider the flat wagon structure on the example of a 4-axle universal flat wagon.

Its bearing structure consists of a frame with eight longitudinal sidewalls 1 and two end walls 25 (Figure 1.1). The welded frame has centre sill 10 with two I-beams of variable height that decreases to the cantilever parts [15, 17]. Lateral longitudinal beams 77 consist of I-beams and bolster beams 12 have the closed cross-sections. The intersections of centre sill 10 and bolster beams 12 are equipped with centre plates 75 reinforced with diaphragms on top. On the stub sills 10, rear support brackets 16 and front support brackets 19 are reinforced and connected with striker 20; transverse straps 17 are used to protect the web of I-beams against abrasion. The lower plates of the bolster beams are equipped with side bearings 14 with reinforcing ribs 13 on top [46].

End beams 21 are reinforced with brackets 22, which support end walls 25 when they are open. When wheeled vehicles drive on the flat wagon, brackets 22 and end walls 25 bear a significant load. End beam 21 has reinforced lever 23 of the coupler release rod. Main cross bearers 7 of the frame have the variable cross-section in height, and intermediate beams 8 have the uniform I-section. The upper plate of cross bearers 7, 8, 12 are lower than the floor level by the height of auxiliary longitudinal beams 6 and 9.

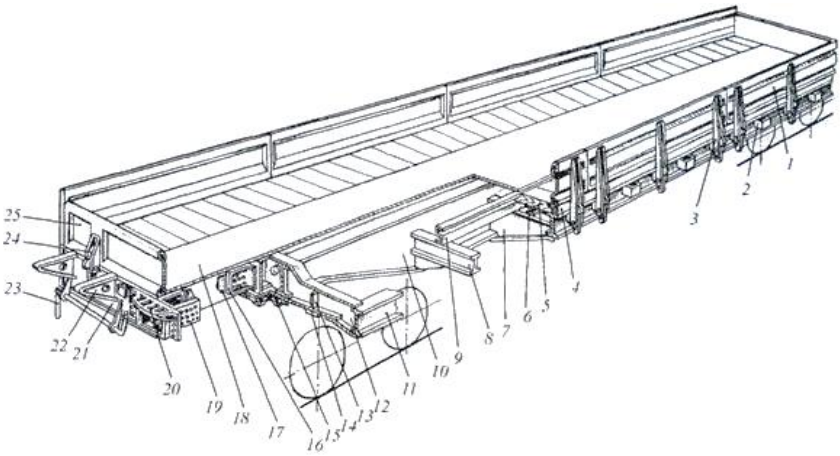


Figure 1.1 – Universal flat wagon

The floor is combined: metal part 18 in the middle and wooden part 5 on the sides. The floor boards are inserted at one end into S-shaped beam 9, and the other end is fixed to longitudinal side beams 11 with special bent element 4. The side longitudinal beams of the frame are equipped with stanchion pockets 2, hinge brackets and stops of wedge-type locks 3 of the side walls. End walls 25 are lower than side walls, in the vertical position end walls are fixed with wedge-type locks 24.

Consider the structural features of new-generation flat wagons produced by Ukrainian leading wagon manufacturers.

The specialized flat wagon mod. 13-7043 (Figure 1.2) is suitable for carrying large-capacity universal containers, packaged freight, different metal profiles, metal plates, and other cargoes that do not require protection against atmospheric agents on 1,520-mm gauge lines in Ukraine and the CIS countries [1].

Brake – automatic air, handbrakes. Running gear – two 2-axle bogies mod. 18-100 type 2 or two 2-axle bogies mod. 18-7055 type 2. Automatic coupler CA3, non-rigid. Absorber of class T1 with increased power consumption.

Figure 1.2 – Flat wagon mod. 13-7043

The specialized flat wagon mod. 13-7024 (Figure 1.3) is suitable for carrying 40′and 20′ universal containers on 1,520-mm gauge lines in Ukraine and the CIS countries.

Brake – automatic air brakes, handbrakes. Running gear – two 2-axle bogies mod. 18-100 type 2 or two 2-axle bogies mod. 18-7055 type 2. Automatic coupler CA-3, non-rigid. Absorber class T1 with increased power consumption.

The flat wagon mod. 13-785 (Figure 1.4) is suitable for carrying packaged freight, various profiles and metal plates, large-capacity universal containers (three 20′ containers or a 40′container and a 20′ container), wheeled vehicles and other cargoes that do not require protection against atmospheric agents.

This flat wagon is equipped with two drop ends (opening angle is 180°), eighteen drop sides (opening angle is 90°), and foldable posts for securing the freight. The wagon can be loaded/unloading using cranes or loaders. Brake – automatic air, handbrakes. Running gear – two 2-axle bogies mod. 18-100 type 2 for 1,435-mm gauge

Figure 1.3 – Flat wagon mod. 13-7024

Figure 1.4 – Flat wagon mod. 13-785

Figure 1.5 – Flat wagon mod. 13-785-01

lines or two 2-axle bogies mod. 18-7055 type 2. Automatic coupler CA-3, non-rigid. Absorber class not lower than T1 with increased power consumption.

The specialised flat wagon mod. 13-785-01 (Figure 1.5) is suitable for carrying packaged freight, various rolled metals (plates, profiles), including steel coils, universal large-capacity containers and other cargoes that does not require protection against atmospheric agents.

Brake – automatic air, handbrakes. Running gear – two 2-axle bogies mod. 18-100 type 2 for 1,435-mm gauge lines, or two 2-axle bogies mod. 18-7055 type 2. Automatic coupler CA-3, non-rigid. Absorber class not lower than T1 or T2 with increased power consumption.

The specialised flat wagon mod. 13-9004M (Figure 1.6) is suitable for carrying packaged freight, wheeled vehicles, and 40′ and 20′ universal large-capacity containers.

The specialised flat wagon mod. 13-7031 (Figure 1.7) is suitable for carrying packaged freight, wheeled vehicles, and 20′ and 40′ universal large-capacity containers.

Figure 1.6 – Flat wagon mod. 13-9004M

Figure 1.7 – Flat wagon mod. 13-7031

Figure 1.8 – Flat wagon mod. 13-7031E2

Brake – automatic air, handbrakes. Running gear – two 2-axle bogies mod. 18-100 type 2 or two 2-axle bogies mod. 18-7055 type 2. Automatic coupler CA-3, non-rigid. Absorber class T1 or T2 with increased power consumption.

The specialised flat wagon mod. 13-7031E2 (Figure 1.8) is suitable for carrying 20´ and 40´ universal large-capacity containers, packaged freight, metal structures, long cargoes and wheeled vehicles.

The flat wagon is designed for the climatic category U (temperate macroclimatic region of the territory of Ukraine) and placement category I (in the open air). Brake – automatic air, handbrakes. Running gear – two 2-axle bogies mod. 18-100 type 2 for 1,435-mm gauge lines or two 2-axle bogies mod. 18-7055 type 2. Automatic coupler CA-3, non-rigid. Absorber class T1 or T2 with increased power consumption.

The flat wagon mod. 13-4117 (Figure 1.9) is suitable for carrying large-capacity containers on 1520-mm gauge lines, can operate on 1,435-mm gauge lines when exchanging the bogies [2, 3].

The characteristics of the flat wagon:

– low tare weight due to new materials, which reduces the material consumption while maintaining the strength parameters;

– for freight containers 1A, 1AA, 1AX, 1B, 1BB, 1BX, 1C, 1CC, 1CX.

Figure 1.9 – Flat wagon mod. 13-4117

The flat wagon mod. 13-9744 is suitable for carrying heavy containers, long cargoes, metal plates and timber (Figure 1.10). The bearing structure of the flat wagon is equipped with two end walls, four stationary side posts, eight timber supports, eight removable side posts, and fitting stops [4].

The flat wagon mod. 13-7133 (13-7133-01) is suitable for carrying universal large-capacity containers, and containers with highly hazardous materials, including tank containers (mod. 13-7133-01) with a maximum weight of up to 36 tonnes, on 1,520-mm gauge lines (Figure 1.11) [45].

Figure 1.10 – Flat wagon mod. 13-9744

Figure 1.11 – Flat wagon mod. 13-7133

Brake – automatic air, handbrakes. Running gear – two 2-axle bogies mod. 18-7055 type 2 (DSTU 7530-2014) or other interchangeable bogies type 2 (DSTU 7530-2014). Automatic coupler CA-3. Absorber class T1 or T3 (model 13-7133-01) with increased power consumption. Suitable for 10′, 20′, 30′, 40′, and 45′ containers in various combinations.

The specialised flat wagon mod. 13-7132 is suitable for carrying 20′, 30′, 40′, 45′ large-capacity universal containers or tank containers on 1,520-mm gauge lines (Figure 1.12) [45]. The flat wagon is equipped with for fixed fitting stops and 20 folding ones for fastening containers. Brake – automatic air, handbrakes. Running gear – two 2-axle bogies mod. 18-7055 type 2 (DSTU 7530) or other bogies of type 2 (DSTU 7530). Automatic coupler CA-3. Absorber class T1. Suitable for 20′, 30′, 40′, 45′ in various combinations.

The specialised flat wagon mod. 13-7138 is suitable for carrying universal large-capacity containers and containers with highly hazardous materials, including tank containers (mod. 13-7138-01) with a maximum weight of up to 36 tonnes, on 1520-mm gauge lines (Figure 1.13) [45].

Figure 1.12 – Flat wagon mod. 13-7132

The flat wagons mod. 13-1796-03 and 13-1796-04 (Figure 1.14) [47] are produced by the Ukrainian wagon manufacturer Azovmash in accordance with TU U 35.2-32258888-563:2006 and have a carrying capacity of 62 tonnes (model 13-1796-03) and 70 tonnes (model 13-1796-04), the tare weight is 31.5 tonnes and 23.6 tonnes, respectively.

The flat wagon mod. 13-4085-01 (Figure 1.15) is produced by the Dnipro VagonMash company [48, 49].

The flat wagon is suitable for carrying universal large-capacity containers of series 1A, 1AA, 1AX and 1C, 1CC, 1SX (GOST 1847), universal and specialised heavy containers with a length of 6,096 mm (20´) and a gross weight of up to 36 tonnes, with a length of 12,192 mm (40´) and a gross weight of up to 40 tons for 1,520-mm gauge lines in Ukraine, the CIS countries, Georgia, Latvia, Lithuania and Estonia.

The structural features:

– easy loading/unloading and effective use of the carrying capacity;

– secure fixation of containers with special devices mounted on the flat wagon frame; and

– suitability for simultaneous transportation of two containers 1C, 1CC, 1CX or one container 1AA, 1A, 1AX.

Figure 1.13 – Flat wagon mod. 13-7138

Figure 1.14 – Flat wagon mod. 13-1796-03

Figure 1.15 – Flat wagon mod. 13-4085-01

The company also produces the flat wagon mod. 13-4117 (Figure 1.16 [50]), suitable for carrying large-capacity containers (GOST 18477) in accordance with the following layout diagrams:

– one container of series 1A, 1AA, or 1AX;
– two containers of series 1B, 1BB, or 1BX;
– three containers of series 1C, 1CC, or 1CX;
– one container of series 1A or 1AA, or 1AX and one container of series 1C or 1CC, or 1CX;

– two containers of series 1C or 1CC or 1CX;

– two tank containers 20´with tanks of 7.150–8.100 mm long, a gross weight of up to 36 tonnes;

– one 20´ tank container with a tank length of 7.150–8.100 mm and a gross weight of up to 36 tonnes.

The flat wagon is used for 1.520-mm gauge lines in Ukraine, CIS countries, Georgia, Latvia, Lithuania and Estonia.

The main bearing elements of the flat wagon are made of high-strength materials.

The flat wagon mod. 13-4147 (Figure 1.17 [51]) is suitable for carrying large-capacity containers (GOST 18477-79) according to the following loading diagrams [48]:

– four containers of series 1C or 1CC, or 1CX;

– three containers of series 1C or 1CC, or 1CX;

– one container of series 1A or 1AA, or 1AX and two containers of series 1C or 1CC, or 1CX;

– two container of series 1A or 1AA, or 1AX and one container of series 1C or 1CC, or 1CX;

– two containers of series 1B or 1BB, or 1BX;

– two containers of series 1A or 1AA, or 1AX;

– two containers of series 1C or 1CC, or 1CX;

– one container of series 1C or 1CC, or 1CX;

– one container of series 1A or 1AA, or 1AX;

Figure 1.16 – Flat wagon mod. 13-4117

Figure 1.17 – Flat wagon mod. 13-4147

The flat wagon is used for 1.520-mm gauge lines in Ukraine, CIS countries, Georgia, Latvia, Lithuania and Estonia.

The structural features of the flat wagon:

– the centre sill, as the main bearing part, has an optimized cross-section along the entire length due to the complex configuration and variable thickness of its elements;

– the front beams of the flat wagon are designed in such a way that the loading length exceeds the wagon length along them. Thus, the flat wagon can be shorter over couplers and the total length of the train is reduced;

– double cross bearers are located at an angle to the centre sill and have cut-outs in the upper and vertical elements, which provides high strength characteristics at minimal tare weight;

– the most critical wagon elements have no transverse welds, which increases the resistance to cyclic (fatigue) loads, which favourably affects the service life of the frame and the entire wagon durability;

– the classic structure of the freight area (flat, without protruding elements) allows using forklift loaders for containers at loading points not equipped with a crane;

– the flat wagon is equipped with an automatic air brake for each bogie, which means the optimal distribution of the forces with which a pad presses the wheelset depending on the loading of the wagon; it ensures braking for an unevenly loaded wagon and increases the traffic safety.

1.2 Structural analysis of articulated flat wagons

In recent years the problem of higher efficiency of container transportation has been addressed by means of articulated flat wagons [Boronenko Yu. P., Belgorodceva T. M., Vasilev S. G., Smirnov N. V. Innovacionnoe reshenie – 120-futovaya platforma sochlenennogo tipa dlya perevozki treh 40-futovyh krupnotonnazhnyh kontejnerov. *Transport Rossijskoj Federacii*. 2009. № 5 (24). S. 56–59; Boronenko Yu. P., Belgorodceva T. M., Kukushina N. A. Vybor konstruktivnih reshenij sochlenennyh gruzovyh vagonov dlya kolei 1520 mm. *Transport Rossijskoj Federacii.* 2013. № 3 (46). S. 3–9]. The special feature of this wagon type is its bearing structure that consists of two half-frames (platforms) interacting through an articulated coupling system (Figure 1.18).

A number of specific requirements are imposed on articulated coupling systems [7, 8]. Thus, they must transmit not only

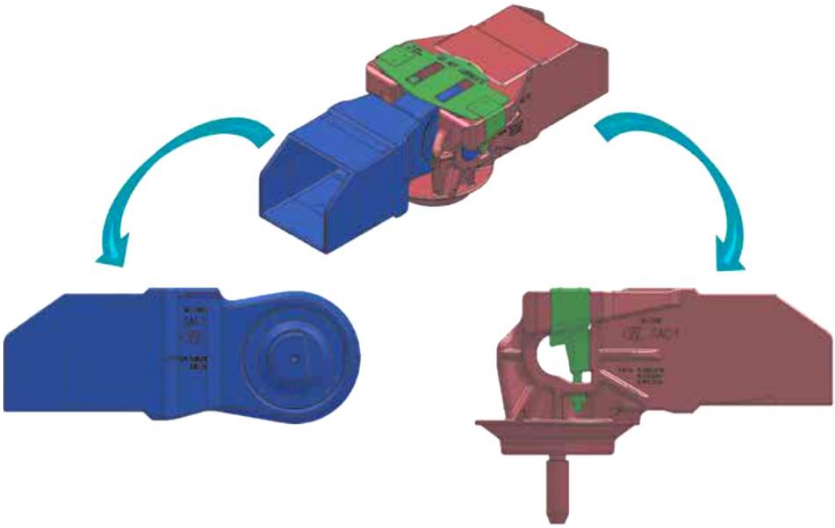


Figure 1.18 – Spherical articulated coupling SAC-1

longitudinal and vertical forces, but also provide the rotation of the platforms relative to each other. There are two main diagrams in worldwide practice: spherical and double-hinge. In North America, the most widely used are SAC-1 Cardwell Westinghouse (Wabtec corporation) and ASF-Keystone (AmstedRail), which provide three-axis rotation, while in Europe, widely used is the two-hinged articulated coupling, which provides rotation in the vertical and transverse axes. The degree of freedom relative to the longitudinal axis is provided at the centre plate/centre bowl joint assembly, which is spherical in the Y-25 bogie. There is no mutual rotation of the two platforms relative to the longitudinal axis.

In North America, each platform of the wagon has an additional support for elastic side bearings. In European countries, almost in all wagons one platform rests on the other through a rigid side bearing, which, in turn, rests on an elastic one.

An analysis of the technical solutions has shown that, when applied for 1,520-mm gauge lines, each has advantages and disadvantages of their own.

When interacted, each platform of the articulated wagon rests on a common bogie with elastic side bearings (Figures 1.19, 1.20 [7, 8]).

As far as the axle load on the middle and end bogies of an articulated wagon differs by 20 %, the separate braking diagram is used, when the loading of each bogie is controlled, accordingly, the pressure to each brake pad of the middle and end bogies (Figure 1.21 [7, 8]). Despite the fact that only the end bogies have handbrakes, the efficiency of controlling the wagon on the standard slope is fully ensured.

The Ukrainian wagon manufacturers Azovmash has also produced the articulated wagon mod. 13-1839 (Figure 1.22 [9, 10]).

Two platforms (the total loading length is 80 ft), mounted on three bogies, have significantly increased the loading capacity and reduced the deflection of each platform by reducing their base to 12 m.

The RM RAIL Ruzkhimmash has developed the articulated flat wagon mod. 13-9894 [11, 12] (Figure 1.23).

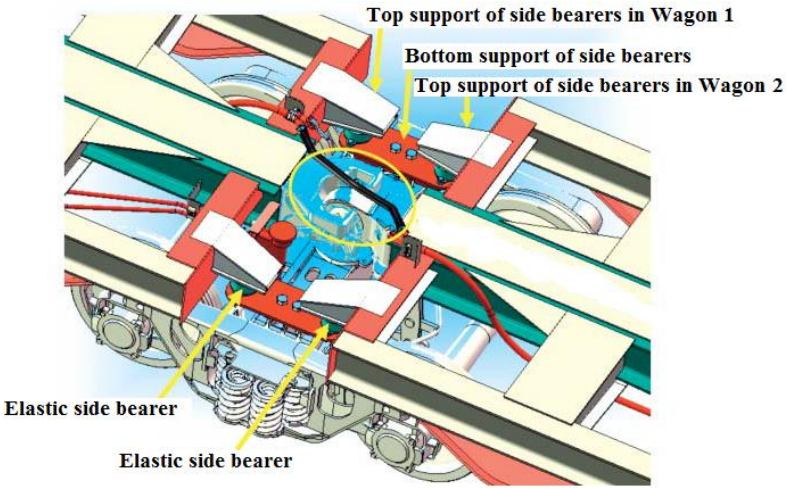


Figure 1.19 – Articulated coupling system and load transfer elements to the bogie

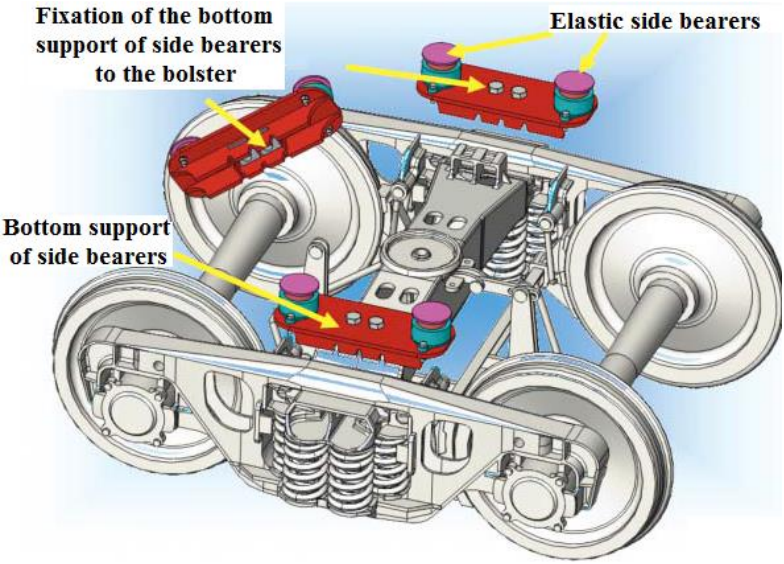
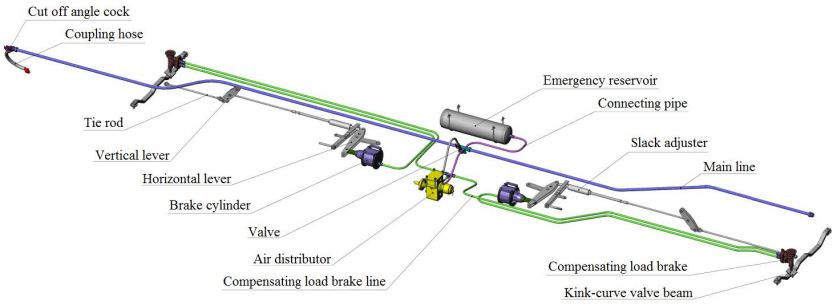


Figure 1.20 – Installation of side bearings and elastic elements on the bogie mod. 18-100

a)



b)

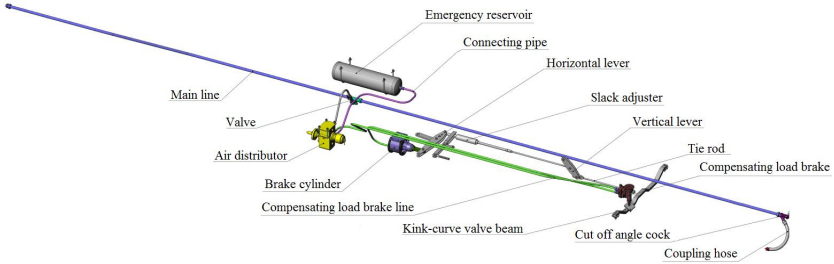


Figure 1.21 – Diagram of the automatic brake of an articulated wagon
a) first platform; b) second platform

Figure 1.22 – Articulated flat wagon mod. 13-1839

Figure 1.23 – Articulated flat wagon mod. 13-9894

The bearing structure of the flat wagon rests on three bogies mod. 18-9890. The design speed is 140 km/h and the tare weight is 30 tonnes at a carrying capacity of 90 tonnes. The car is designed according to the 02-VM standards (for international wagons with 4,650-mm height and 3,150-mm width for 1,435-mm lines).

Articulated flat wagons are also used in European countries. Thus, there is a two-platformed flat wagon on three bogies [13] (Figure 1.24), which is suitable for carrying 20′, 40′ containers and swap bodies. The wagon meets the standards of TSI, EN, UIC and has also the TEN GE marking on. The wagon payload is 108.8 tonnes.

The wagon is suitable for carrying containers according to UIC 592 (ISO 668) and swap bodies according to UIC 592 and UIC 596-6:

– Series 1 freight containers – 1CX, 1C, 1CC, 1AX, 1A, 1AA; + 1BX, 1B, 1BB;

– Symmetrical swap bodies – (20), 40, + (30)(1); + (21), 22, 23, 24, (26), (29); + (31);

– Asymmetrical swap bodies – NA + (81), 82, (84), (85), (86); + (60).

Loading possibilities are in accordance with loading diagram.

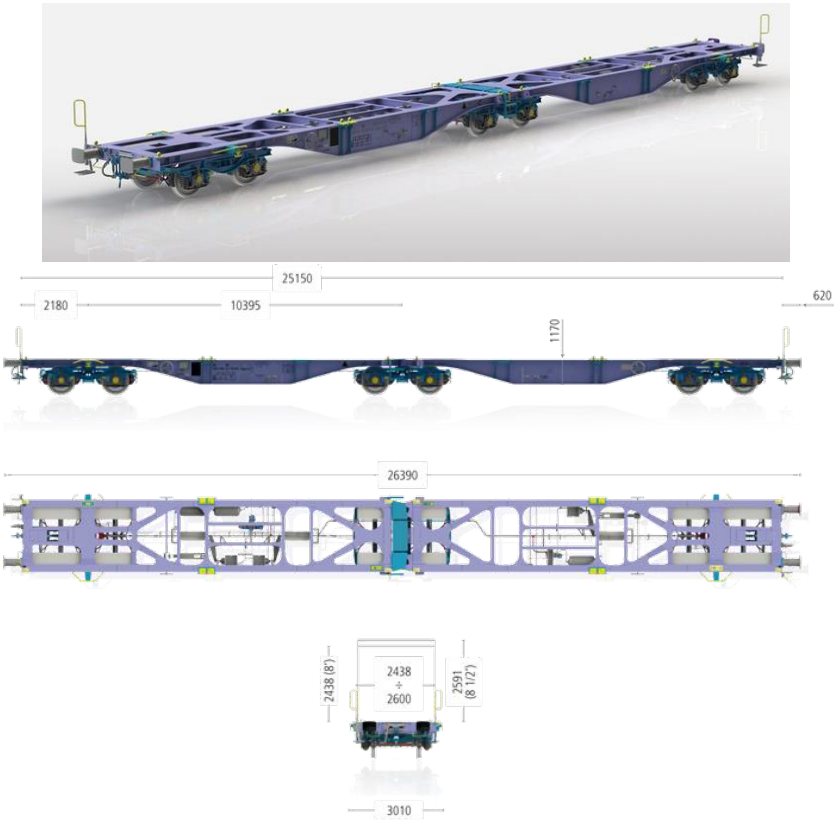


Figure 1.24 – 6-axle articulated flat wagon mod. Sggrss 80´

A similar flat wagon is manufactured by the Kryukovsky Railway Car Building Works (Figure 1.25) [45].

The specialised articulated flat wagon is suitable for carrying containers according to ISO 668 and UIC 592-2, and swap bodies series 1, 2, 3, 3a and 4 according to UIC 592-4 with a maximum length of 12,192 m for 1,435-mm gauge lines, with a maximum axle load of 22.5 tonnes in the brake regime 'S' (100 km/h) and 20 tonnes if unloaded in the brake regime 'SS' (120 km/h), climatic conditions is T1 at the temperature from –25 °C to + 40 °C [45].

Figure 1.25 – Articulated flat wagon Sggrss 80´

The wagon is equipped with:

– three bogies type Y25Ls (s) d1-K with wheelsets type BA004 and brake shoes with two composite pads type C810;

– automatic air brake SW-GP-A(K)-3 × 10´´ (brake cylinder for each bogie), according to UIC 541-1 and UIC 543, respectively, and handbrakes for the middle bogie;

– buffers with the category A that meets the Standards EN 15551, with a stroke of 105 mm and a EUROPAD spring element (energy capacity is 40 kJ). Buffer disc is 450 × 340 mm;

– coupling device RG 12 with a minimum breaking load of 1.5 MN, in compliance with the Standard EN 15566;

– coupling hooks with a minimum breaking load of 1,500 kN, in compliance with the Standard EN 15566;

– screw ties with a minimum breaking load of 1,350 kN, in compliance with the Standard EN 15566;

– Talbot-type coupling system.

The Kryukovsky Railway Car Building Works produces also intermodal flat wagons type Sggmrss 90´ (Figure 1.26) [45].

The specialised articulated flat wagon is suitable for carrying large-capacity 20´, 30´, 40 ´and 45´ containers according to UIC 592-2

Figure 1.26 – Flat wagon Sggmrss 90´

and swap bodies series 1, 2, 3, 3a and 4 according to UIC 592-4 with a maximum length of 13.6 m for 1,435-mm gauge lines, climatic conditions T1 (temperatures from −25 °C to +40 °C) according to TSI RST WAG [45]. The flat wagon consists of 6-axis type Sggmrss 90´, the maximum loading length of a half-frame is 2 × 13.82 m. The wagon belongs to the FII category according to Standard EN 12663-2, complies with Recommendations TSI RST NOI, ERA, Standard EN, relevant UIC leaflets and the General Contract of Use for Freight Wagons (AVV).

The wagon is equipped with:

– three bogies type Y25Ls (s) d1-K with wheelsets type BA004 and brake shoes with two composite pads type C810;

– automatic air brake SW-GP-A(K)-3 × 10´´ (brake cylinder for each bogie) according to UIC 541-1 and UIC 543, respectively, and handbrakes for the middle bogie;

– buffers category A that comply with Standard EN 15551, with a stroke of 105 mm, with a EUROPAD spring element (energy capacity 40 kJ). Buffer disc is 450 X 340 mm;

– coupling device RG 12 with a minimum breaking load of 1.5 MN that complies with Standard EN 15566;

– coupling hooks with a minimum breaking load of 1,500 kN that complies with Standard EN 15566;

– screw ties with a minimum breaking load of 1,350 kN that complies with Standard EN 15566;

– Talbot-type coupling system.

The 4-axle flat wagon Sgnss 60´ is suitable for carrying containers and swap bodies of various types (20´, 30´, 40´), classified in UIC 592 [13], (Figure 1.27). This wagon design meets the requirements of TSI, EN, UIC standards and has TEN GE marking for traffic operation. The UIC 596-6 is fulfilled by the wagon that has also "C" marking on; a payload of 70.8 tonnes is possible.

This wagon is suitable for carrying:

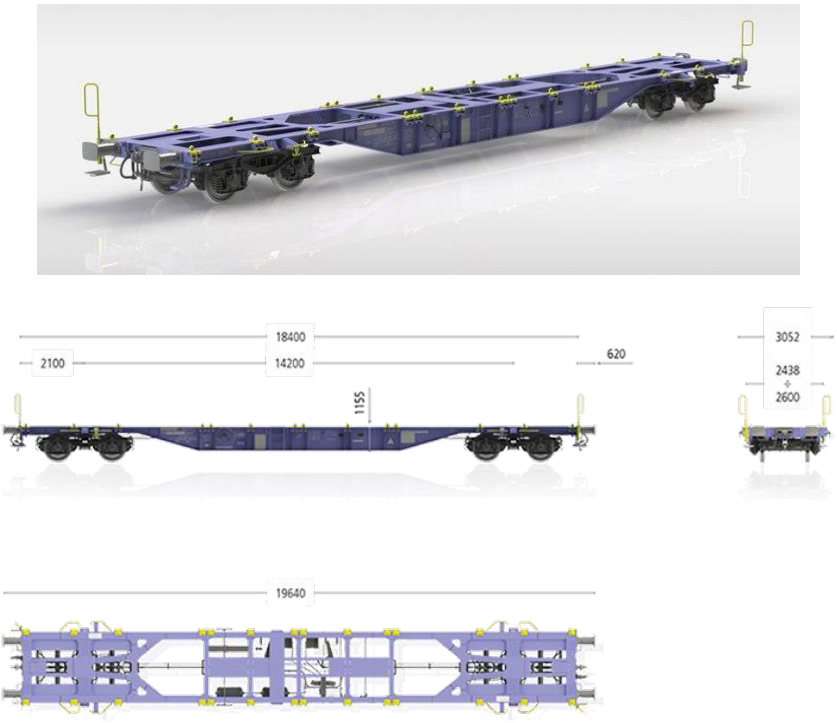


Figure 1.27 – 4-axle articulated flat wagon mod. Sggrss 60´

– containers classified in UIC 592 (ISO 668) and swap bodies classified in UIC 592 in accordance with UIC 596-6;

– Series 1 containers – 1CX, 1C, 1CC, 1BX, 1B, 1BB, 1AX, 1A, 1AA;

– Symmetrical swap bodies – (20), (21), 22, 23, 24, (26), (29), (30), (31), 40, 42, (44), (45);

– Asymmetrical swap bodies – NA + (81), 82, (84), (85), (86) (1); + (60) (2) (3);

– Load possibilities are in accordance with loading diagram.

The 8-axle short coupled flat wagon mod. Sffggmrrss is a low two-platformed wagon on 4 bogies (8 axles) that is suitable for carrying 20′, 30′ and 40′ containers and swap bodies classified in UIC 592 in symmetrical and asymmetrical load configurations on the entire length (Figure 1.28) [13].

The total length of the wagon is optimized using a short coupling system between two low platforms.

This wagon design meets the requirements of TSI, EN, UIC standards and has TEN GE marking for traffic operation.

The UIC 596-6 is fulfilled by the wagon that has also "C" marking on; a payload of 89.0 tonnes on both platforms is possible.

The wagon is suitable for carrying containers classified in UIC 592 (ISO 668) and swap bodies classified in UIC Leaflet 596-6:

– Series 1 freight containers – 1CX, 1C, 1CC, 1BX, 1B, 1BB, 1AX, 1A, 1AA;

– Symmetrical swap bodies – (20), (21), 22, 23, 24, (26), (29), (30), (31), 40, 42, (44), (45);

– Asymmetrical swap bodies – (60), (81), 82, (84), (85), (86), (91), (94), 96;

– Loading possibilities are in accordance with loading diagram.

The two platformed 8-axle flat wagon mod. FLA 2 × 40′ is suitable for carrying UK containers [13], (Figure 1.29). The platforms are connected by the tie rod. The wagon has the LTF13 bogie, the wheel diameter is 540 mm; the wagon is designed according to TSI, EN, Group Standards for UK traffic operation.

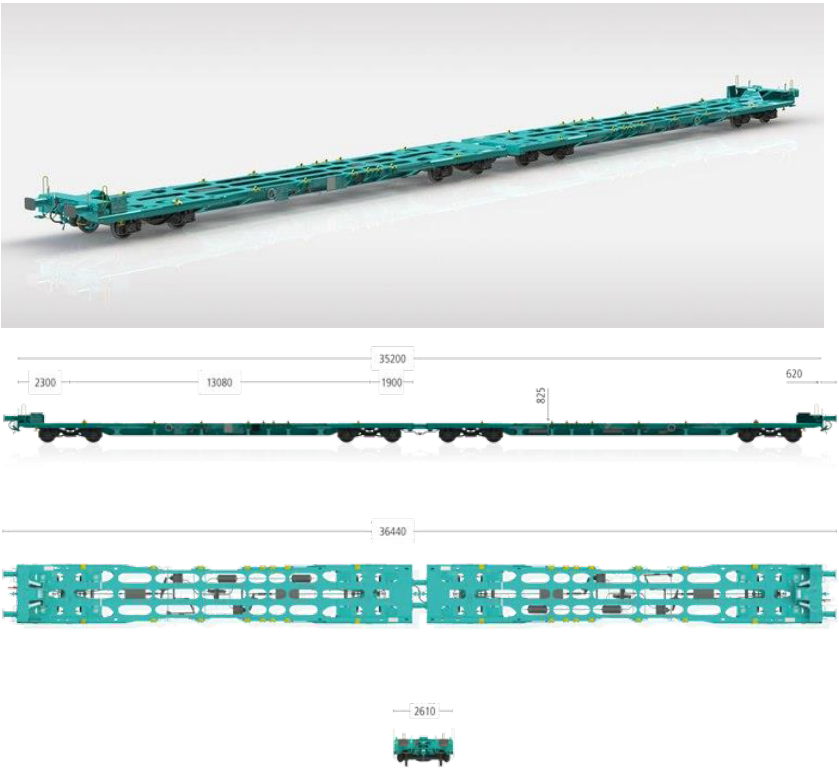


Figure 1.28 – 8-axle short coupled flat wagon mod. Sffggmrrss

The wagon can be used for carrying 20´ and 40´ containers specified in UIC within W8 track. Loading possibilities are in accordance with loading diagram.

The 8-axle flat wagon mod. FKA 2 × 50´ has two platforms connected by the tie rod and is suitable for carrying containers [13], (Figure 1.30). This wagon is designed and approved to run in the UK and Continental Europe according to TSI, EN and Group Standards for traffic operation.

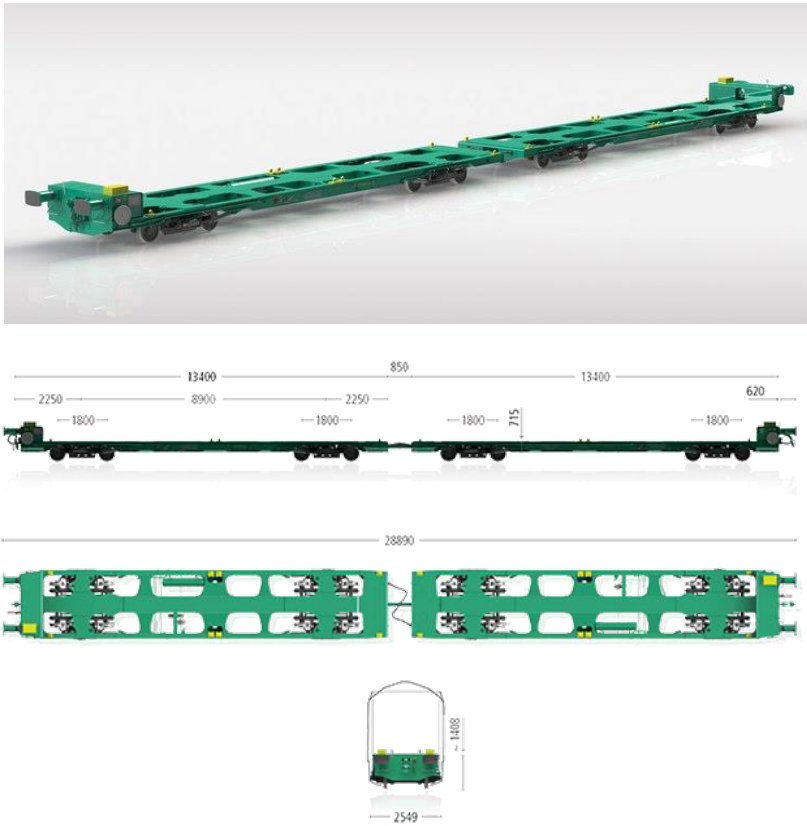


Figure 1.29 – 8-axle flat wagon mod. FLA 2 × 40´suitable for carrying UK containers

The two platformed 8-axle short coupled flat wagon mod. FEA 2 × 60´ is suitable for carrying containers withing W8 gauge [13], (Figure 1.31). The wagon design meets the requirements of TSI, EN, Group Standards for UK traffic operation.

Capabilities of one platform:

– three 20´ containers according to ISO;
– two 30´containers according to ISO;
– a 20´contaner + a 40´ container according to ISO.

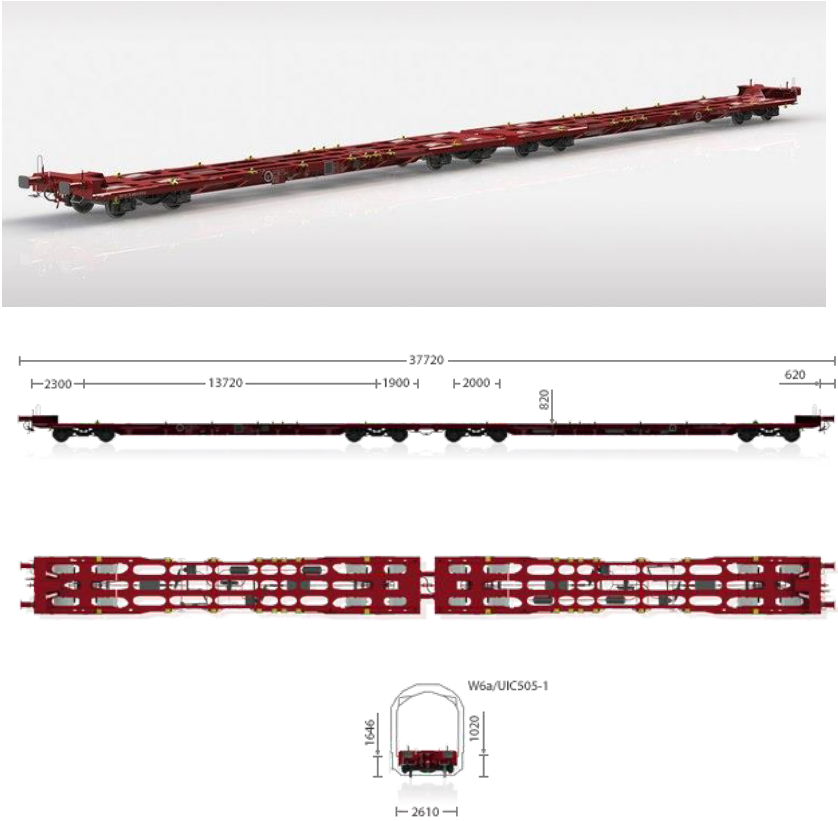


Figure 1.30 – 8-axle flat wagon mod. FKA 2 × 50´ for carrying containers

The 4-axle UK low deck wagon mod. FAA 40´ UK is suitable for carrying cube containers within W8 gauge [13], (Figure 1.32). Due to the S-section the frame reaches a height of up to 700 mm using standard bogies. The wagon is in accordance with TSI, EN, Group Standards for UK traffic operation.

The wagon can accommodate the following containers:

– 40´ container with 35 tonne maximum weight according to ISO;

Figure 1.31 – 8-axle short coupled flat wagon mod. FEA 2 × 60´

– 20´ container with 35 tonne maximum combined weight (maximum weight of one 20´ does not exceed 17.5 tonnes) according to ISO;

– 20´ container with 25 tonne maximum weight according to ISO;

– compatible 40´ swap bodies can be accommodated up to a maximum width of 2.5 m and height of 9´6´´.

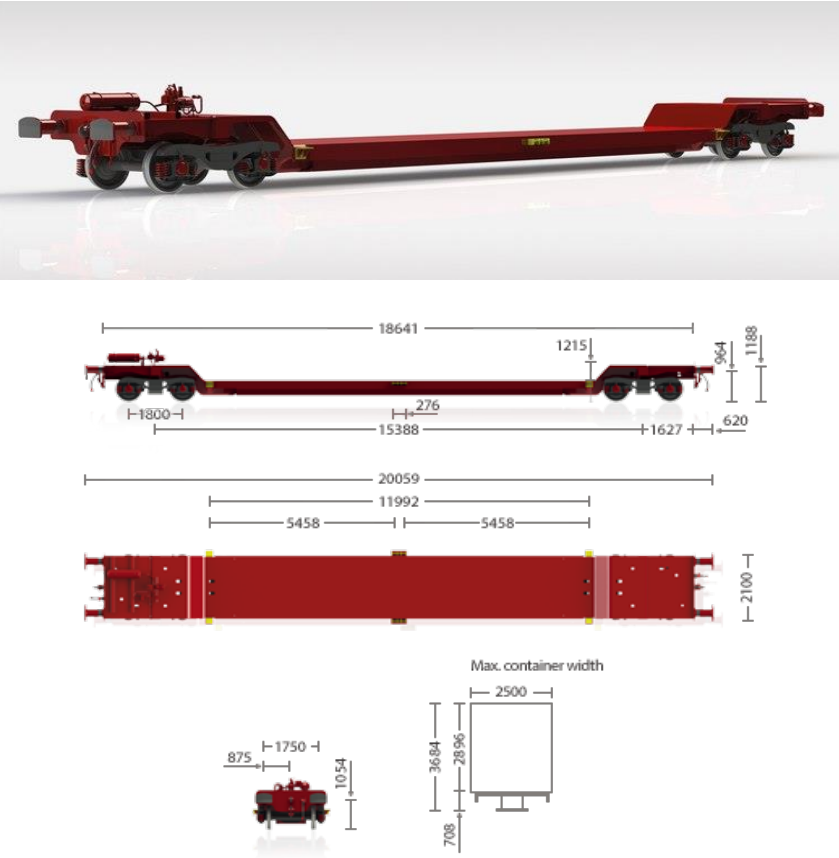


Figure 1.32 – 4-axle UK low deck wagon for cube containers mod. FAA 40 UK

The two platformed 6-axle articulated flat wagon mod. Sggmrss 90′ on three bogies is suitable for carrying 20′, 30′, 40′ and 45′ containers, as well as swap bodies [13], (Figure 1.33). The wagon design meets the requirements of TSI, EN, UIC standards and has TEN GE marking for traffic operation. The UIC 596-6 is fulfilled by the wagon that has also 'C' marking on.

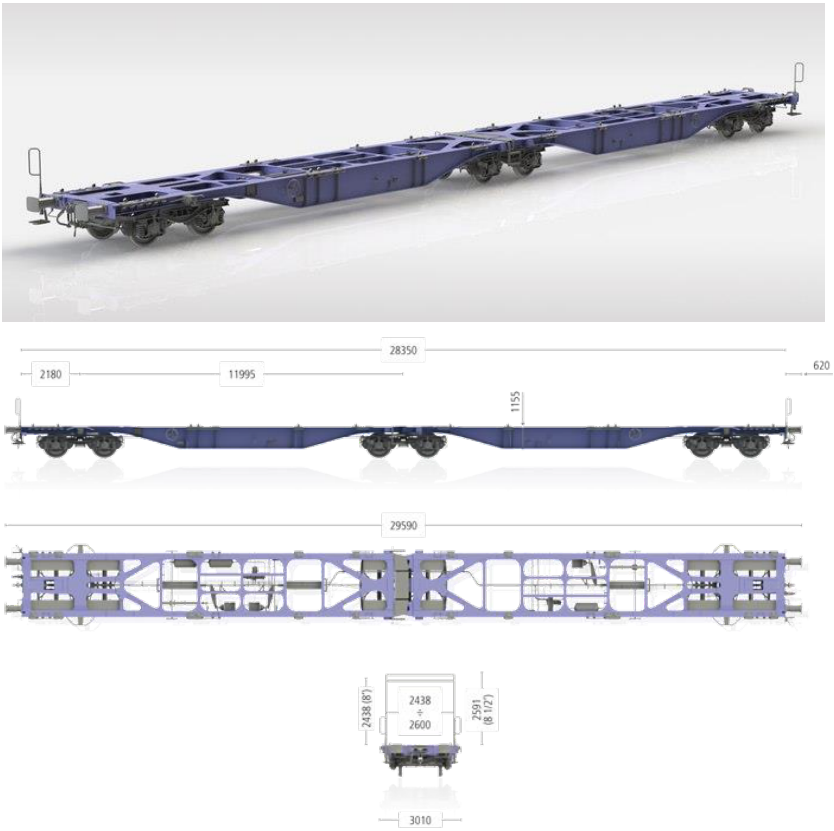


Figure 1.33 – 6-axle articulated flat wagon mod. Sggmrss 90´

The wagon accommodates the following containers:

– Series 1 freight containers – 1CX, 1C, 1CC, 1BX, 1B, 1BB, 1AX, 1A, 1AA, 1EE;

– Symmetrical swap bodies – (20), (21), 22, 23, 24, (26), (30), (31), 40, 42, (44), (45);

– Asymmetrical swap bodies – (60), (81), 82, (84), (85), (86), (91), (94), 96.

Loading possibilities are in accordance with loading diagram.

1.3 Analysis of the main damages to the bearing structures of flat wagons in operation

The bearing structures of a flat wagon in operation is exposed to significant loads conditioned by various factors. Among them are shunting impacts at increased speeds, compliance of containers relative to the frame due to technological gaps in the fitting stops/container fittings pairs, faulty loading/unloading operations, etc. All of these cause damage to wagon components. The main damages to the flat wagon frame and fitting stops are given below [14, 74].

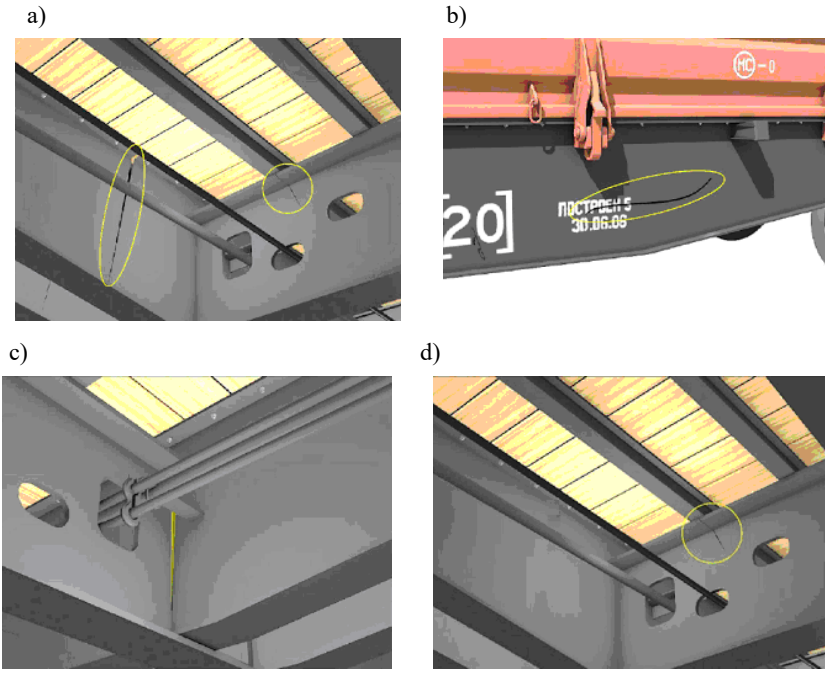


Figure 1.34 – Main damages to the bearing structure of a flat wagon

a) fracture or crack transferring from the horizontal plate to the vertical one on the central sill, bolster or end beam; b) longitudinal cracks in the frame beams; c) breakage in the weld of the fasteners; d) cracks or breaks in the upper or vertical plate of the cross bearer

e) g)

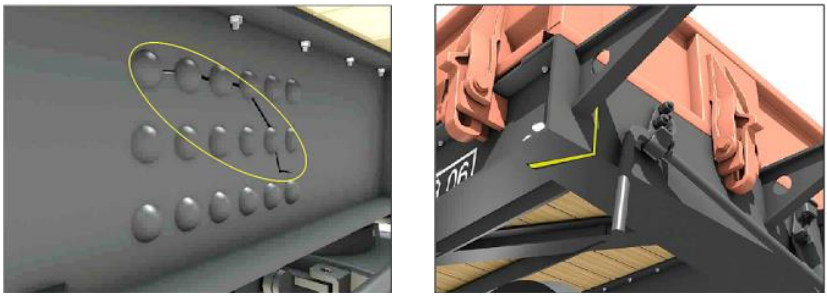


Figure 1.34 – (p. 35)
e) vertical, longitudinal or inclined cracks passing through the holes for bolts or rivets; g) cracks or breaks in the vertical plate of the end beam of the frame

a) b)

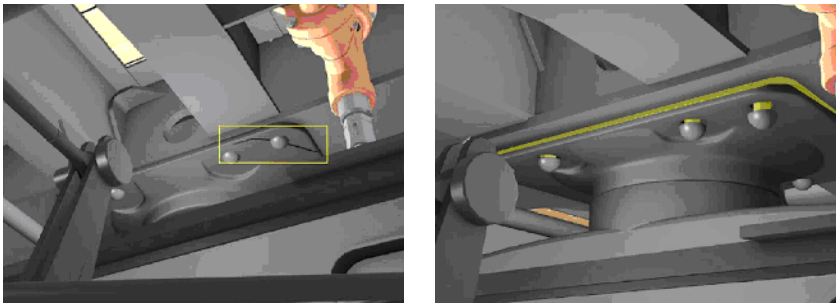


Figure 1.35 – Main damages to the centre plate arrangement of the flat wagon
a) cracks in the centre plate (flange); b) loosening of the riveted or bolted fastening of the centre plate to the flat wagon frame

The study shows that most damages to the bearing structure of a flat wagon occurs in the areas of interaction between the beams due to the action of significant dynamic loads on the flat wagon in operation.

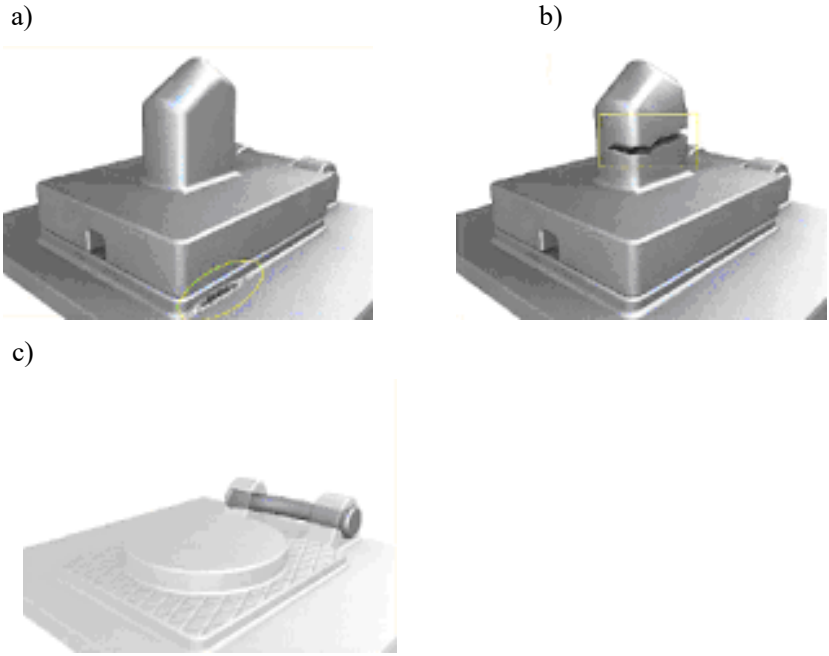


Figure 1.36 – Main malfunctions of freight fastening units in the flat wagon
a) crack in a weld; b) break of a stop; c) bending of a pin

Conclusions to Part 1

1. A structural analysis of flat wagons used for carrying containers produced by Ukrainian manufacturers is carried out; their basic technical characteristics are studied and compared.

2. The structural features of articulated flat wagons produced by Ukrainian and foreign manufacturers are analysed. The articulated coupling system for platforms and their interaction with the running gears are considered. The special design characteristics of the air brakes of articulated flat wagons are described.

The main technical characteristics of articulated flat wagons used for 1,435-mm gauge lines are analysed.

3. The main damages to the bearing structure of the flat wagon in operation are analysed. They include fractures or cracks in the frame components, broken welds, etc.

The main damages to fitting stops on flat wagons in operation are also considered. They include cracks in welds, breakage of stops, bending of pins, etc.