SECTION 2
LOAD OF CONTAINERS UNDER MAIN OPERATING MODES

2.1 Main load diagrams of the containers transported by vehicles

The strength of containers, as well as the transport safety of vehicles can be improved at the design stage by taking into account the loads arising under the most unfavourable operating modes.

Based on the analysis of regulatory documents used for designing and testing containers, it was found that one of the most important loads acting on the container transported is the longitudinal load [16]. Therefore, the longitudinal stiffness of the container structure is thoroughly tested. The longitudinal stiffness tests are carried out in order to verify the ability of the container to withstand external longitudinal loads, in particular compression or tension which act on the container transported with an acceleration of 2 g.

In the strength calculations, the dynamic load, caused by this acceleration, is applied horizontally through the lower openings of the pair of lower corner fittings of the container, first in the direction of the secured end (compressing), and then in the opposite direction (stretching) (Fig. 2.1).

For box-type containers, the strength of the end walls is tested in order to check the ability of the container to withstand the internal forces from the cargo, which arise during its transportation by rail and are caused by an acceleration of 2 g. The load diagram for the load on the end wall is shown in Fig. 2.2.

The sidewalls of box-type containers are also tested for strength and the ability to withstand the internal forces from the cargo, which arise during sea transportation. Fig. 2.1 does not indicate the vertical load that acts on it.

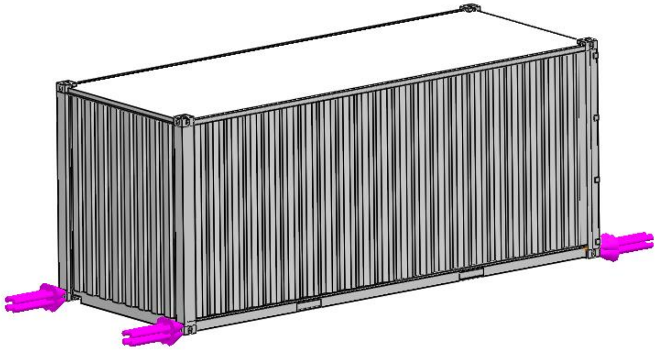

Figure 2.1 – The diagrams of loads to container fittings tested for the longitudinal stiffness

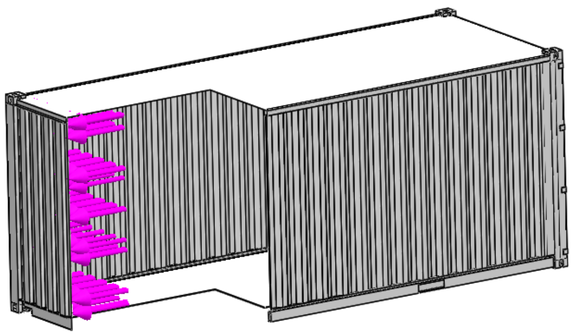

Figure 2.2 – The diagram of loads to the end wall of the container

By taking into account the symmetrical container design, only one of its walls is tested. The wall of the container with the door is subject to an evenly-distributed internal load of 0.6 Pg (Fig. 2.3). The container is fastened by its lower corner fittings to prevent it from transverse displacements. The deflection of the vertical walls of the tested container must not exceed 40 mm relative to the plane formed by the outer surfaces of the four corner fittings on each side of the container.

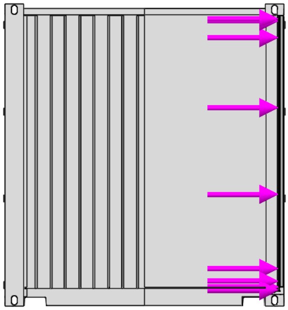

Figure 2.3 – The diagram of loads applied to the container sidewall

For the roofed container, the roof is also tested for strength. A load of 300 kg is evenly distributed across an area of 600 × 300 mm in the weakest zone of the rigid roof of the container (Fig. 2.4).

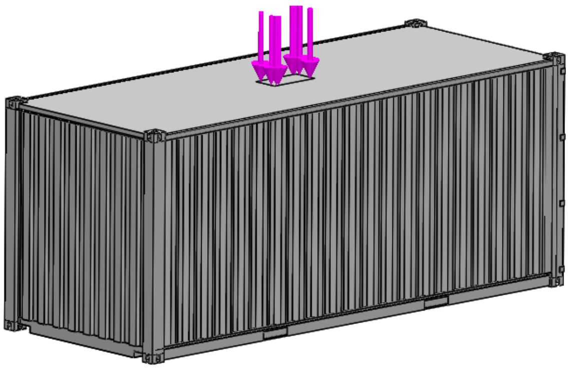

Figure 2.4 – The diagram of loads applied to the container roof

The floor of box-type containers is also tested for strength in order to check its ability to withstand the concentrated dynamic load during loading/unloading operations with forklift or other devices inside the container. The tests are carried out with testing equipment (bogie) with elastic massive tires and with a load of 36.3 kN on each of the two wheels of the bogie or loader. The load diagram of the container floor with the test equipment moving relative to it is shown in Fig. 2.5.

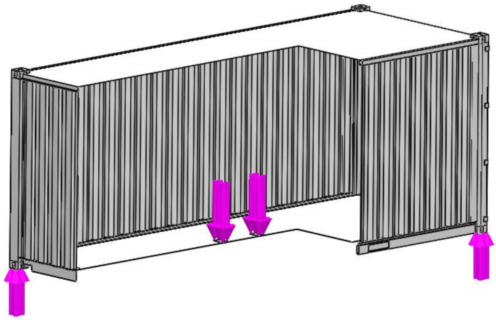

Figure 2.5 – The load diagram for the container floor when test equipment moves relative to it

The containers are also tested for transverse stiffness to check the ability of any container (except for 1D and 1DX) to withstand the forces arising from the movement of the vessel and causing a lateral distortion of the container structure.

An external force of 150 kN is applied in the transverse direction, separately or simultaneously, to each of the upper corner fittings of one sidewall of the container parallel to the base plane and to the end wall plane of the container (Fig. 2.6).

Containers (except for 1D and 1DX) are also tested for longitudinal stiffness to check their ability to withstand the forces arising from the movement of the vessel and causing longitudinal distortion of the container structure.

An external force of 75 kN is applied, separately or simultaneously, to each of the upper corner fittings of one end wall of the container parallel to the base plane and the sidewall plane (Fig. 2.7). The forces are applied first in the direction of the upper corner fittings, and then in the opposite direction.

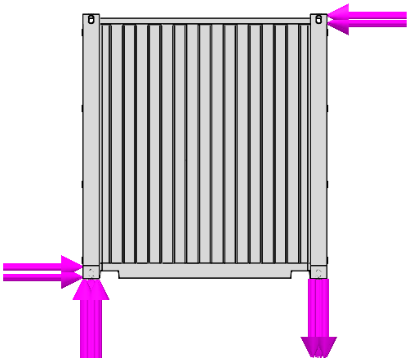

Figure 2.6 – The diagram of loads when the container is tested for transverse stiffness

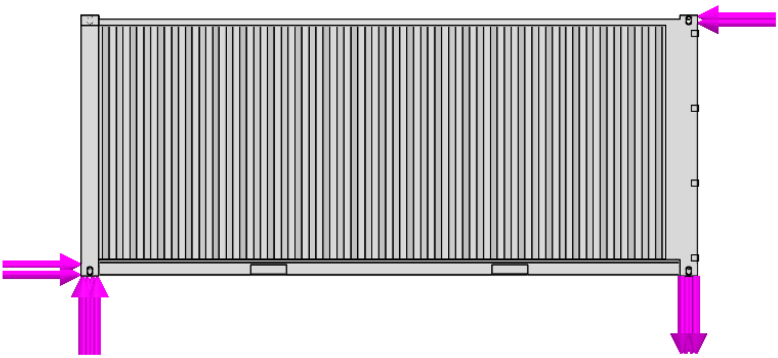

Figure 2.7 – The diagram of loads when the container is tested for longitudinal stiffness

The hopper containers are tested for longitudinal fastening to check their ability to withstand the inertia forces from the cargo on the container and on the connection of the body and the frame under a longitudinal acceleration of 2Rg.

The hopper containers are also tested for transverse fastening to check their ability to withstand the inertia forces of the cargo on the container and on the connection of the body and the frame under a lateral acceleration on the vehicle of Rg.

2.2 Load diagrams of the containers during loading/unloading operations

The loading/unloading operations are conducted with container corner fittings and openings for fork grippers [16]. The strength of containers during loading/unloading operations are thoroughly tested during their design and calculation.

One of the tests is stacking that checks the ability of a fully loaded container to withstand the load arising from the upper loaded containers; the accelerations arising when the vessel in motion and the eccentricity between the loaded containers in the stack are taken into account.

The forces acting on the container are specified in the relevant regulatory documents according to the container type. The diagram of forces on the lower container in a stack is shown in Fig. 2.8.

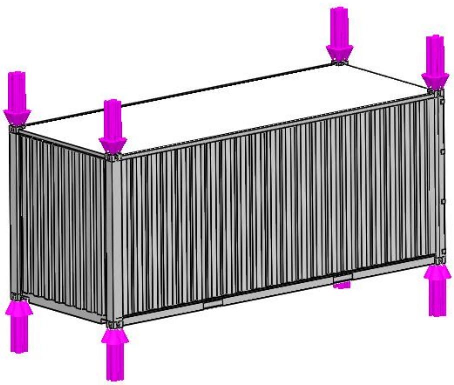

Figure 2.8 – The diagram of the forces on the lower container in a stack

For container types (except for 1D and 1DX), the test load is determined based on the nine-tire stack.

When a container is loaded onto a vehicle (e.g., a flat wagon), it is lifted by four upper corner fittings. The design stage of the container includes its calculating and the subsequent testing of the prototype. The tests check the ability of any container (except for 1D or 1DX) to withstand the loads arising when it is lifted by four upper corner fittings vertically. The tests for 1D or 1DX containers include the load arising when the container is lifted by the four upper corner fittings and when the lifting forces act at an angle of less than 30° to the vertical and 60° to the horizontal.

This test is also carried out in order to check the strength of the floor and the base frame. The diagram of the forces on the container when it is lifted by the upper corner fittings is shown in Fig. 2.9.

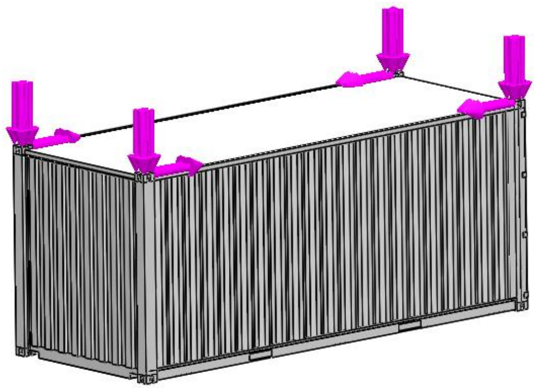

Figure 2.9 – The diagram of forces on the container when it is lifted by upper fittings

However, Fig. 2.9 does not show the load on the container from the cargo. As far as the ropes fixed with hooks to the upper corner fittings are placed at some angle to them, the load on the fittings is decomposed according to the rope placement angle.

If containers are lifted by other loading/unloading devices, the load diagram can take a different form.

The container can also be lifted by four lower corner fittings. Therefore, the stages of design and manufacture must include appropriate tests. They are aimed at checking the ability of the container to withstand the loads arising when the container is lifted by four lower corner fittings using lifting devices that interact with the container only through the lower corner fittings and attached to a single traverse beam placed above the middle of the container in the transverse direction.

The container must have such a uniformly distributed load across the floor area that the sum of the container's own weight and the test load be 2R.

The diagram of forces on the container when it is lifted by the lower corner fittings is shown in Fig. 2.10.

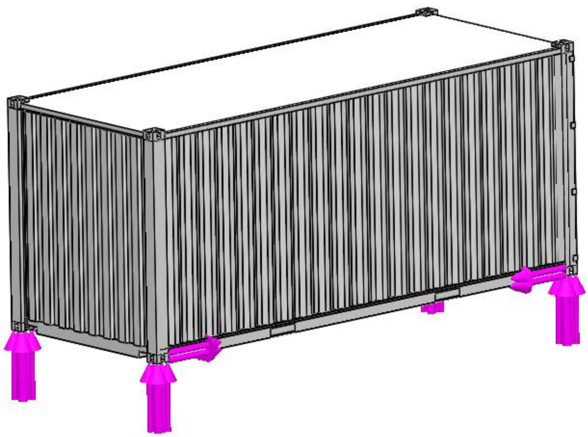

Figure 2.10 – The diagram of forces on the container when it is lifted be lower fittings

The diagram of loads to the lower corner fittings may differ from that shown in Fig. 2.10, depending on the loading/unloading devices used.

For 1CC, 1C, 1CX, 1D, and 1DX containers, the tests include their lifting with fork grips (if any). Here, the load is evenly distributed over the floor area of the container so that the sum of the container's own weight and the test load be equal to 1.6R. The diagram of forces on the container when it is lifted using fork grips is shown in Fig. 2.11.

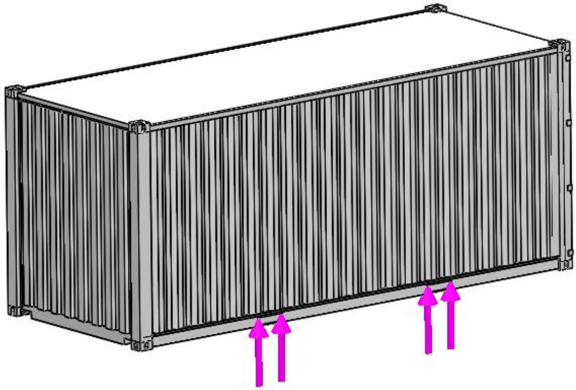

Figure 2.11 – The diagram of the forces on the container when it is lifted by fork grippers

Fig. 2.11 does not show the load acting on the container from the cargo.

Conclusions to Section 2

1. The basic load diagrams for the container transported by transport means are presented. They include: tests for longitudinal stiffness, tests of the end walls and sidewalls of the container, tests of the container roof, the tests of the container floor when the testing equipment moves on it; tests of the container for transverse stiffness, and the tests of the container for longitudinal stiffness. The special features of these tests and the loads in these diagrams are described.

2. The load diagrams of a container during loading/unloading operations are presented; they include the loading of the container during stacking, the loading of the container when it is lifted by upper corner fittings and by lower ones, the load of the container when it is lifted by fork grips. The corresponding load diagrams for the container are also given.