Contruss
Engineering Company

Comparison of ConTruss permanent filler with single U-boot filler

Contruss Engineering Company

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Introduction:

The use of innovative technologies as well as optimizing methods in constructions have been developed in recent years. One innovative system practiced in constructing of slab is Contruss voided slab system, which was issued and certified in 2014. In this report, the voided slabs with typical single U-boot filler will be illustrated and compared to the Contruss permanent filler, from technical and economic point of views.

1- Introduction of voided slab system with permanent U-boot filler

1-1- Voided slab history:

The origins of concrete voided slab applied in constructions, can be traced to the long-times ago, as some samples belong to last century. The initial voided slab with I-shaped section, that is known as a double-sided voided slab along with permanent fillers, first recognized in 1995 in Europe. It was created by the use of spherical hollow fillers as permanent ones in the concrete slab.

In 2003, Italian Daliform company initiated changing the manner of manufactured permanent fillers, created them as rectangular cuboid ones. In comparison to the spherical as special forming, the new fillers enriched them with a reduction in self-weight and concrete consumption.

1-2- Advantages of voided slab for spans beyond 7 meters

a) two-way function:

In many types of concrete slabs, the transfer of loads occurs in the plane of floor with straight trajectory along one direction of the slab, that makes the transfer trajectory longer, which will increase beams and columns dimensions as well as ceiling weight. On the contrary, the two-way voided slab distributes the loads equally in two directions on supports. By creating middle voids and increasing height, the voided slab systems will reduce slab weight as well as increasing the moment of inertia of the section in two directions.

b) Creating a flat soffit (smooth bottom surface of the ceiling):

Presenting smooth bottom surface of the ceiling gained by applying voided slabs will be accompanied by following advantages:

- achieving long spans without beams
- reduced height of structure as well as increased number of floors
- creating flat intrados floor without drops

Note that removing thick beams is totally depended on the structural system. By providing shear walls or in the structures with total height less than 10 meters, the elimination is possible; Unless, the presence of beams (large or flat soffit) is essential.

c) lightening, fewer columns and high strength in earth quake:

- reduction in dead load that leads to involving of fewer columns; the result is less applied load on the foundation that leads to less deep foundation excavation.
- reduction in dead load applied on the ceiling that leads to decreased lateral force, ultimate shear and consequently increased structural strength in earthquake.
- reduced deflection as well as increased slab rigidity

d) flexibility in architectural design:

Thanks to the use of voided slab with permanent fillers, creating long span will be possible. From the architectural point of view, providing long span will allow suitable flexibility in scheme as well as increasing useful space; additionally, it will provide possibility of using reallocation.

e) Suitable operation as an acoustic subjected to noise, heat and vibration:

High rigidity due to the existence of two solid concrete layers and mutually perpendicular ribs, contribute the slab to operate properly in transmission of heat, noise and vibration.

Note: concrete ceiling is not appropriate insulation in transmission of airborne noise; but the double-sided voided slab is capable of acting as an acoustic system, since the presence of hollow space inside the slab.

f) Providing possibility of great openings in the slab:

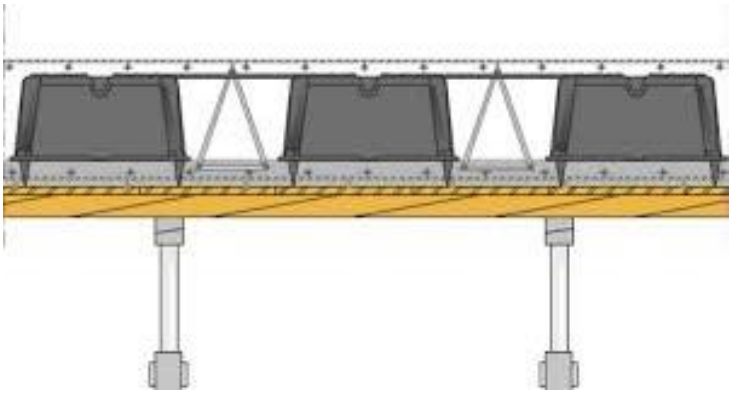
Structural function of slab as a rigid diaphragm for distributing seismic loads among supports does matter much. Creating openings, from the structural point of view, might disorder the loads distribution in floors. The double-sided voided slab, due to the high moment of inertia and much indeterminate degrees, will form a rigid and solid slab that act properly as a diaphragm, even though in the presence of large openings.

2- Technical and economic comparison of single U-boot voided slab system with Contruss voided slab system

a) Incompatible with regulations because of performing the ceiling in two steps:

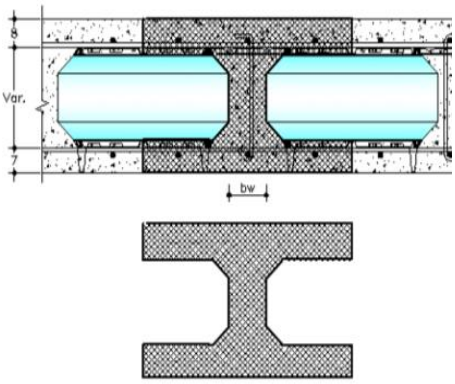
As you know U-boot fillers are bowled-shape, the lower part of the filler is open as placing single U-boot filler on the ceiling. Concrete-pouring of the ceiling should be performed in two steps: pouring of the concrete at the lower part of the filler to get a little hard to prevent the entrance of concrete inside the filler at first step; and performing total concrete- pouring of the ceiling at second.

As shown in the figure, the concrete is pouring to lower level of the filler, then the process is interrupted until the concrete is hardened and finally the total concrete-pouring of the ceiling will be performed. Note that this process will make possibility of creating cold joint in the ceiling, that will require special study to avoid.

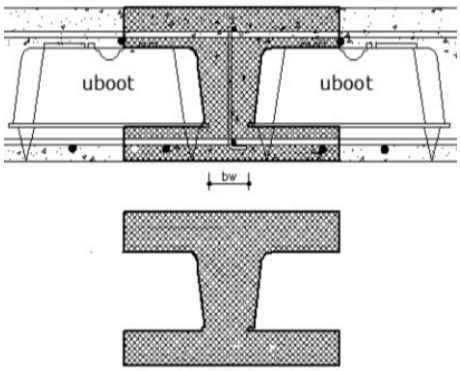


In voided slabs with permanent fillers, high slump concrete will be needed to penetrate totally in the lower part of the fillers. By performing the concrete-pouring in one step, this type of concrete will enter inside the fillers and filling the middle voids of the slab.

On the other hand, because of integrated essence of the Contruss filler, the concrete-pouring of the ceiling can be performed continuously in one step with higher rate and without creating cold joint. Moreover, the special and unique form of the Contruss filler (curvature at the connection zone between web and flanges in the rib) will contribute the concrete flowing the lower part of the fillers easily.



Contruss filler



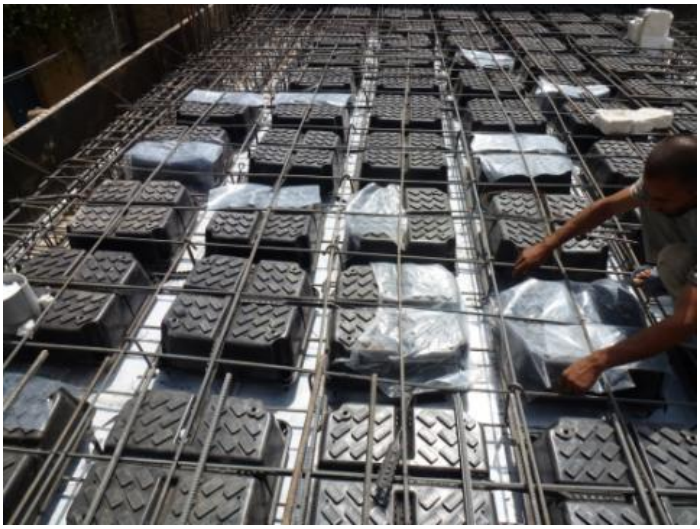
Single U-boot filler

Voided slab created with Contruss filler

b) Breaking of the fillers during installation:

As producing the U-boot fillers by recycling plastics, the fillers strength will be reduced subjected to heat interactions and fractured under constructional loads. The fractured fillers will remain in the ceiling because they are enclosed between the upper and lower reinforcement. Therefore, the concrete will fill inside the fractured fillers, leading to more loads than predicted on the ceiling.

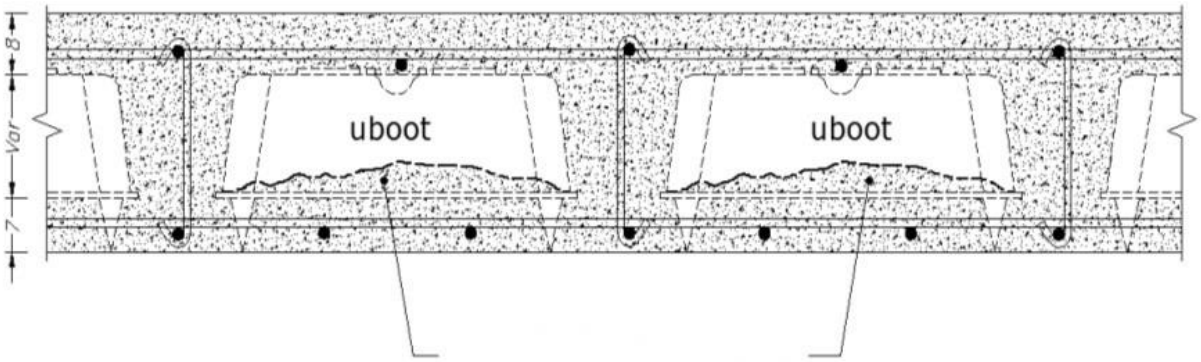
This problem happens frequently in projects using U-boot fillers, because replacing the fractured and defected fillers with new ones is so difficult. Penetrating of the concrete inside the fillers will reduce strength of the ceiling and increasing its weight.



On the contrary, the Contruss filler material and strength is quite different. According to the test performed by the Road, Housing and Urban Development Research of Iran, this filler is capable of bearing the loads by 150 kg applied on a surface with area of 64 cm^2. This amount of load is much higher than the typical loading applied on the fillers in the ceiling.

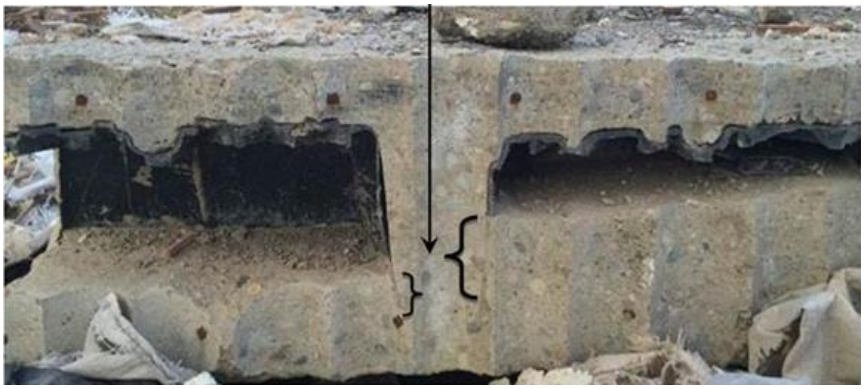
c) Increased weight of the ceiling due to ascending of the concrete in U-boot fillers:

The minimum slump for consuming concrete in U-boot fillers should be 14 to 16 cm in order to penetrate the lower part of the filler. This type of concrete can easily ascend in the U-boot, filling 80 percent of the filler.



Penetrating of the concrete inside fillers

Some companies tried to fix this problem by practicing trays at the lower of the fillers. Beside imposing much more money, the trays will usually separate from the fillers, leading to penetration of concrete inside the filler.



U-boot filler section- penetrating of the concrete inside the filler

Contruss filler section- impermeability and stability of the filler

d) honeycombs in concrete at lower part of the filler:

The most important factor to prevent from creating honeycombs in concrete in voided slabs is referred to form of the fillers. By creating two concrete layers, the concrete will flow simply in the lower part of the fillers. Trapezodial- shape of the single U-boot filler will prevent penetrating of the concrete, creating major problems during installation. This problem has been resolved by special form of Contruss filler, that is existence of curvature at the corner zone of the fillers.

Non-penetrating of concrete to the lower part of the filler will make possibility of creating honeycombs in concrete and reducing strength of the ceiling.

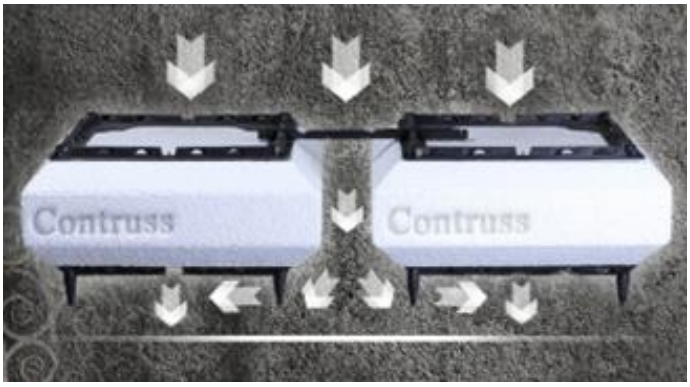
In some cases, trapped air is observed at the lower part of U-boot filler that makes the region remain hollow.

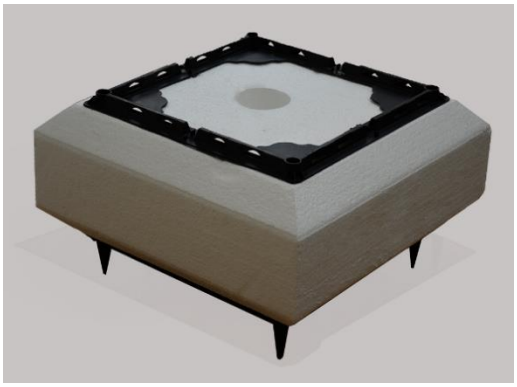
Ceiling created by Contruss system

Ceiling created by U-boot system

By increasing dimensions of Contruss filler in the double-sided voided slab, consuming concrete will be reduced, though it may cause honeycomb in concrete at lower regions. Thanks to the engineers involved at the research and development department of Contruss company, an exhaust hole can be drilled at the middle of Contruss filler in order to facilitate concrete pouring as well as preventing from created honeycombing concrete.

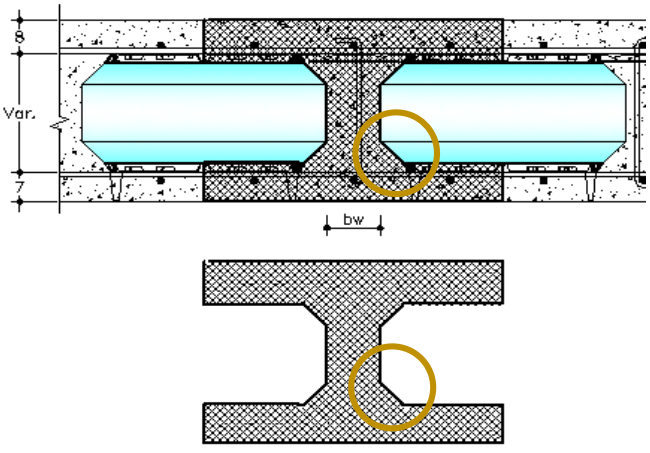
Manufacturing in various dimensions and drilled forming are the unique superior benefits of the Contruss filler that will make it possible to create the most optimized voided slab.



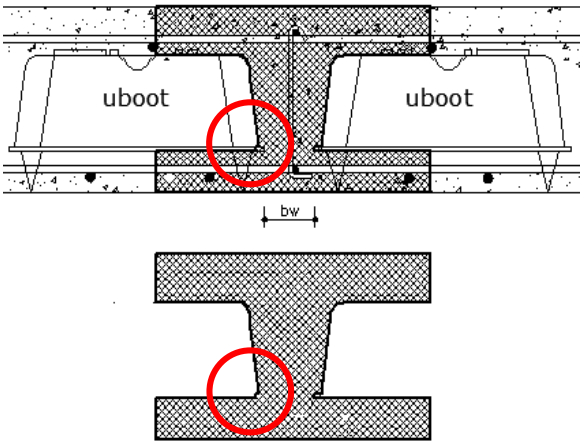


e) Stress concentration in the shear web of ribs:

Providing I-shaped ribs is the major advantage of two-way voided slab. Due to the special forming of Contruss filler, as shown in figure 4.12, the connection zone between web and flanges in the rib is curved and shear force will transfer properly, which prevent it from creating stress concentration. In the U-boot slab, due to the creation of sharp zone at the joint connection, stress concentration will be developed, leads to cracking of the rib.



Contruss filler section



U-boot filler section

f) Qualified to pass in compression, breakage, punch and overturning tests:

Contruss filler has qualified to pass many structural tests by relevant authorities in the Middle East. One of these tests has been accomplished by the Road, Housing and Urban Development Research Center of Iran on Contruss filler. The test evaluate the strength of the filler subjected to fire, overturning, shear punch, deformations and breakage under loading.

The Contruss filler has been passed this test successfully in 2018 and qualified to resist over bending fracture, shear punch and overturning in an experimental test subjected to a load as much as 150kg applied on a surface with dimension of 8*8cm.

g) Non-providing appropriate reinforcement cover:

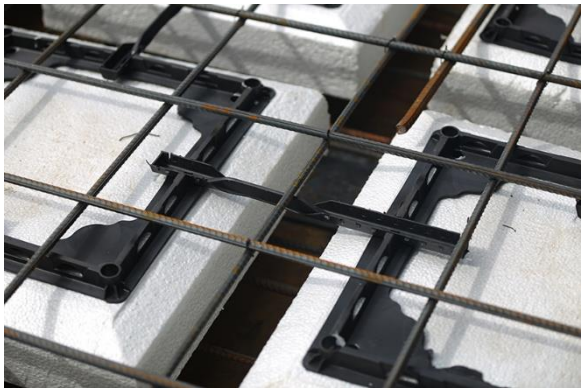
According to the valid regulations for voided slabs, predicting at least 2 cm cover between reinforcement and filler is necessary.

U-boot fillers produced by Daliform company have strips in two orthogonal directions as shown in the figure. These strips are responsible for providing minimum reinforcement cover. In other words, the reinforcement should be placed just on the strips, which will be a limited factor for designing of upper reinforcement mesh of U-boot fillers.

Inappropriate practical details for providing cover on U-boot filler

Tray on the Contruss filler provides appropriate cover

Due to the existence of tray on the Contruss filler, the reinforcement will be located at distance of 2 cm from the filler surface, providing appropriate reinforcement cover. Therefore, the upper reinforcement mesh will be designed and installed without any restrictions.



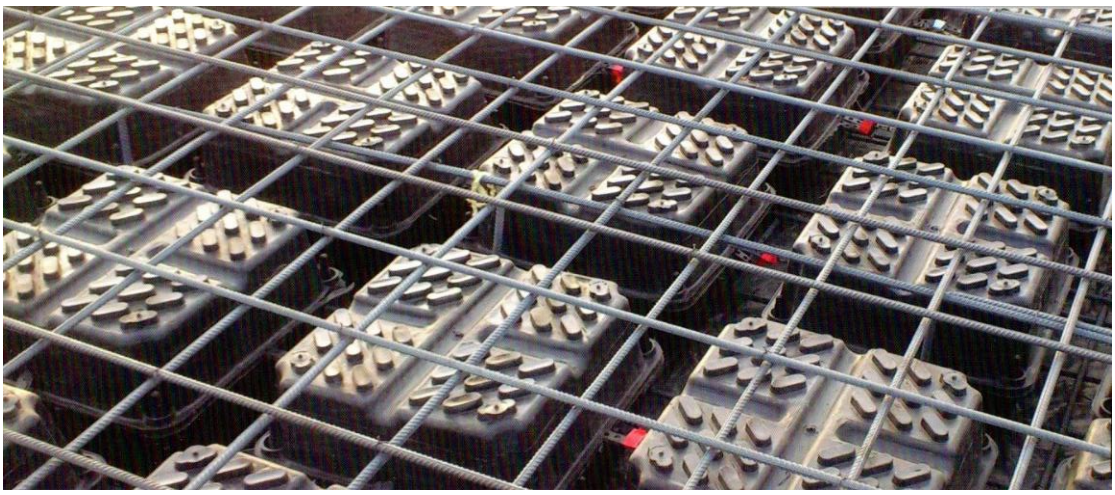
Trays to maintain reinforcement of Contruss filler

Moreover, the dimensions of the legs of the fillers are variable, that will contribute to change the thickness of lower concrete.

h) Irregular ordering of the fillers in the ceiling:

Based on the valid regulations for voided slabs, the fillers should be stable and placed on orthogonal directions beside each other. Observing of this limitation required existence of appropriate belt in the fillers. In the U-boot fillers, there is no belt or it is inefficient if existed as shown in the figure.

Lack of appropriate belts in the fillers will result in displacement of the fillers and irregular ordering during installation. In some cases, the fillers are connected to each other by adhesion or reinforcement wire, which will increase the costs and duration of the installation.



Voided slabs are often designed for large spans. Therefore, regular ordering of the fillers and existence of appropriate belts are necessary. The belts have two main tasks: first, keeping the fillers regularly in determined distance beside each other and creating an integrated shear web to keep the fillers stable during concrete-pouring, reinforcement working and vibrating; second, using the belts as vaults for placing the upper reinforcement of the ribs.

An important point about the belts of Contruss filler is the variability of its dimensions that makes it possible to adjust the distance of the fillers.

i) Restrictions in size and dimensions:

Because of producing in factory according to the determined dimensions, changing the fillers sizes and dimensions to achieve the optimum mode will be not possible.

But in the Contruss filler, designing and producing of fillers in various dimensions will be possible. The dimensions of a prismatic formed Contruss filler can be 45 to 60 cm with the height of 12 to 65 cm, that will provide the most optimum slab construction, technically and economically.

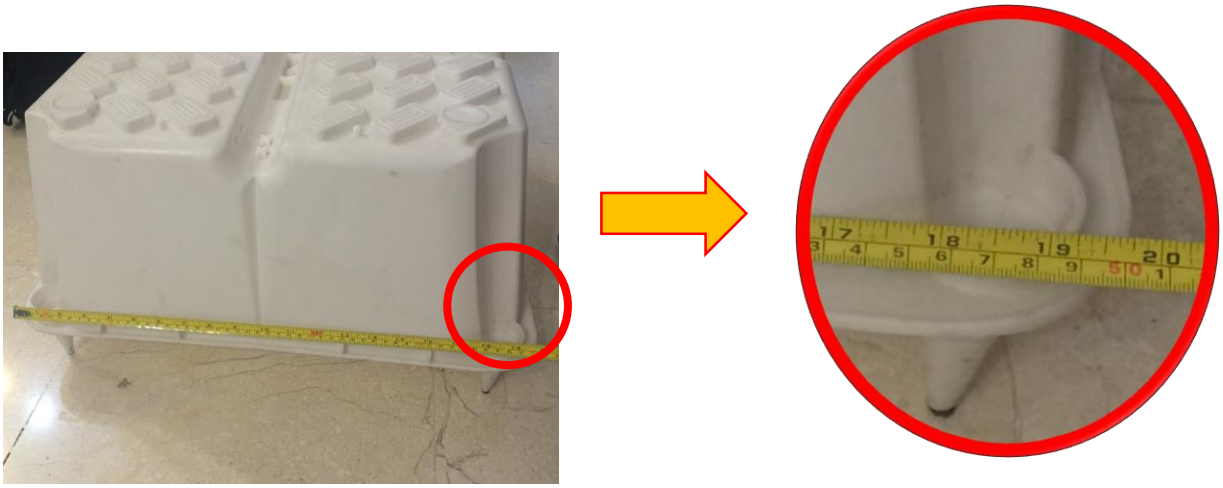
Optimized Grade

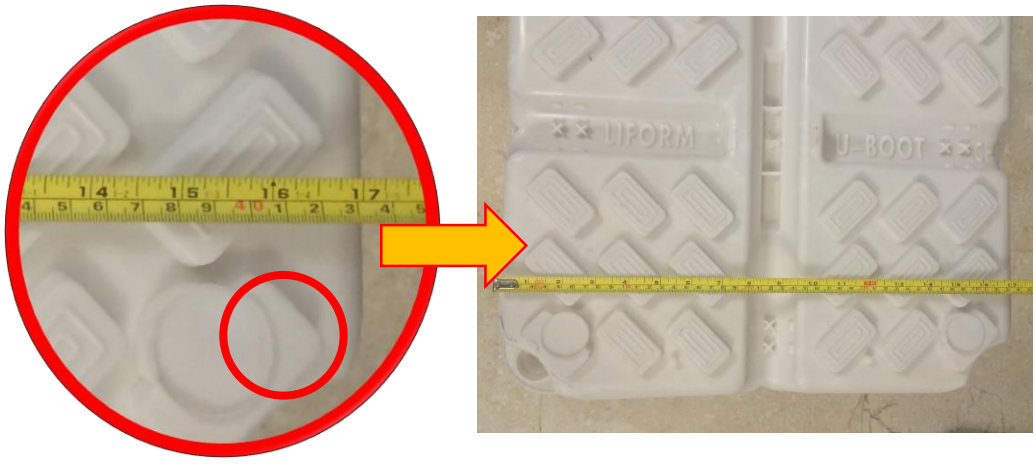
U-boot Grade

j) Declaring unreal dimensions:

Available U-boot fillers in market are known as U-boot-52, however, by accurate measurement, we can observe that the area that become hollow inside the slab is equal to 46*46 cm.

The volume of U-boot-52 is an imperfect pyramid in which by accurate measuring, it is observed that length of lower dimension of the filler is 52 cm with two edges equal to 1 cm. Therefore, the pure lower dimension of the filler is 50 cm. The upper dimension of the filler is gained 43 cm. Consequently, the average dimension of the upper and lower parts of the filler will be 47 cm.



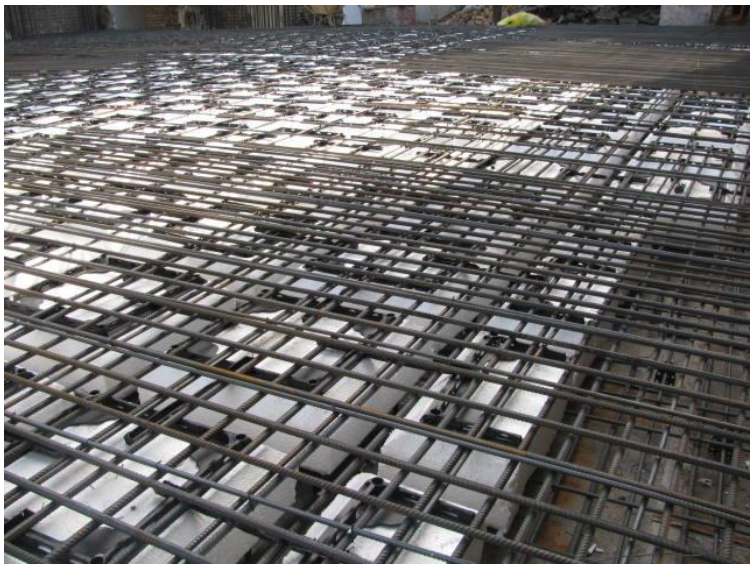


For example, Daliform company has declared volume equal to 42600 cm^3 for U-boot fillers with height of 20 cm. By dividing this amount of volume to the height of 20 cm, the real dimensions of U-boot filler will be equal to 46 cm. In the other words, the amount of volume related to U-boot 20 should be considered as a cuboid with dimension of 45 cm. As a consequence, the shear web of the ribs will be equal to 16 cm.

By considering U-boot 52 with 10-cm-shear web, the consuming concrete for real web will be 15 cm. Therefore, by increasing the amount of concrete in the U-boot slab system, the weight and costs of the slab will be much higher than the Contruss permanent filler.

k) Capable to be slashed in workshop:

By using polystyrene, the Contruss filler can be slashed down easily by means of saw to fit the required spaces in correspondence of irregular scheme with various span length. This unique qualification will make it easy to position the fillers at the corner region on site.



l) Capability of creating exhaust hole on the fillers:

By increasing dimensions of filler in the double-sided voided slab, consuming concrete will be reduced, though it may cause honeycomb in concrete at lower regions. Thanks to the engineers involved at the research and development department of Contruss company, an exhaust hole can be drilled at the middle of Contruss filler in order to facilitate concrete pouring as well as preventing from created honeycombing concrete.

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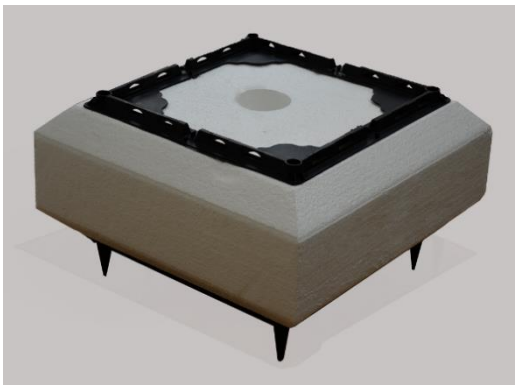
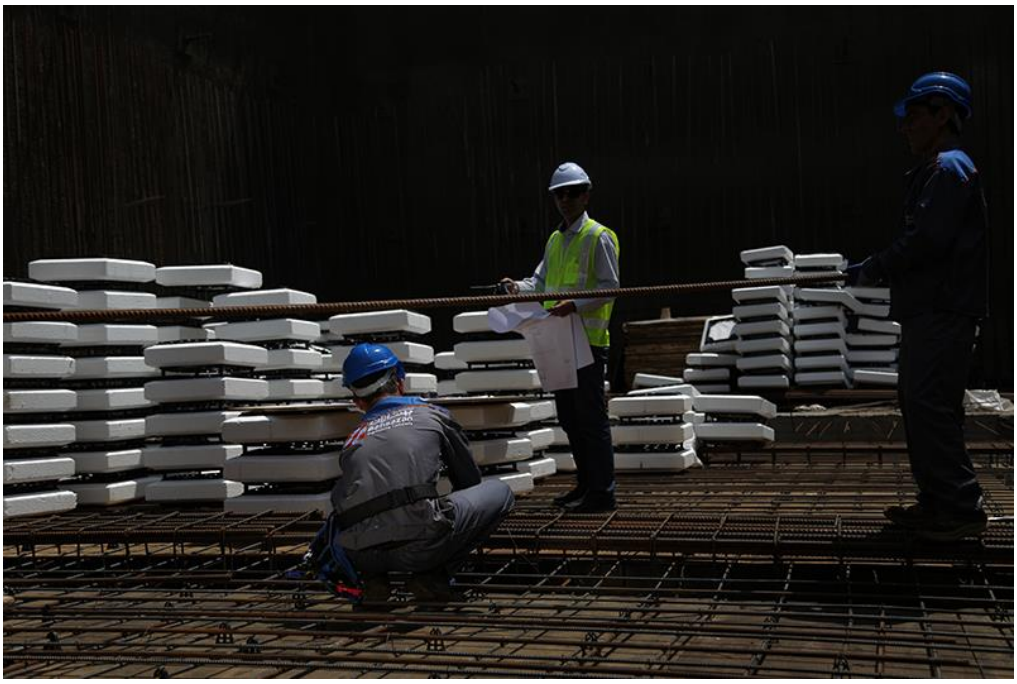


m) Indicators applied to determine the thickness of upper concrete layer:

The concrete pouring of ceiling is going to be performed after the positioning of fillers and rebar, while it is difficult to determine required concrete volume. Thanks to the use of indicators over the upper tray, the concrete pouring level will be determined simply that permits accurate concrete pouring.

n) Easy to store and transport:

By using legs, the Contruss fillers are attached totally upon each other, which will simplify storing as well as transporting to site.



3- Conclusion:

For spans more than 7 meters, voided slabs with permanent fillers will be more efficient, technically and economically. For this purpose, Single U-boot filler is accompanied by some technical and practical defects, which have been resolved by Contruss fillers. The defects of single U-boot filler are mentioned in the following:

- need for integrated concrete-pouring in one step to avoid from creating cold joint
- penetrating of the concrete inside the filler
- low strength of the filler subjected to constructional loads because of recycling essence
- non-providing of appropriate reinforcement cover
- lack of appropriate belts to keep the fillers stable
- creating honeycombs concrete at lower part of the filler because of trapezoidal forming
- impossible to change dimensions to achieve optimized scheme
- impossible to cut the filler to fit the site
- impossible to create exhaust hole in the filler