Contruss
Engineering Company

Comparison of ConTruss voided slab system with Slab-beam system

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, slab-beam system will be illustrated and compared to the Contruss voided slab system, from technical and economic point of views.

1- Slab-beam system introduction:

This system is a traditional method practiced for constructing of ceiling, includes main and secondary beams along with two-way solid slab. Thick beams used in this system make it possible to provide long spans, but common distances between the beams are ranging from 3 to 6 meters in this system. By increasing span length, the numbers and height of beams will be increased.

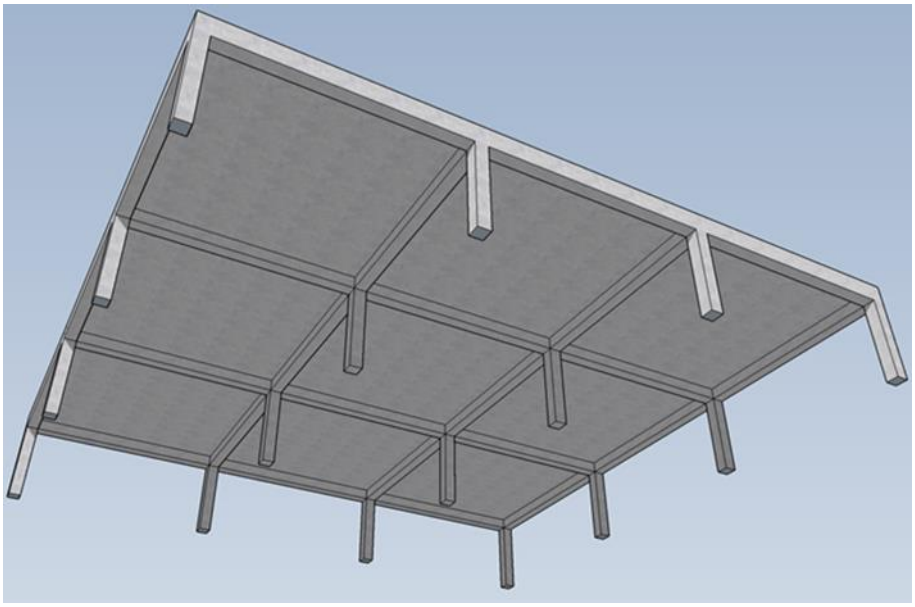
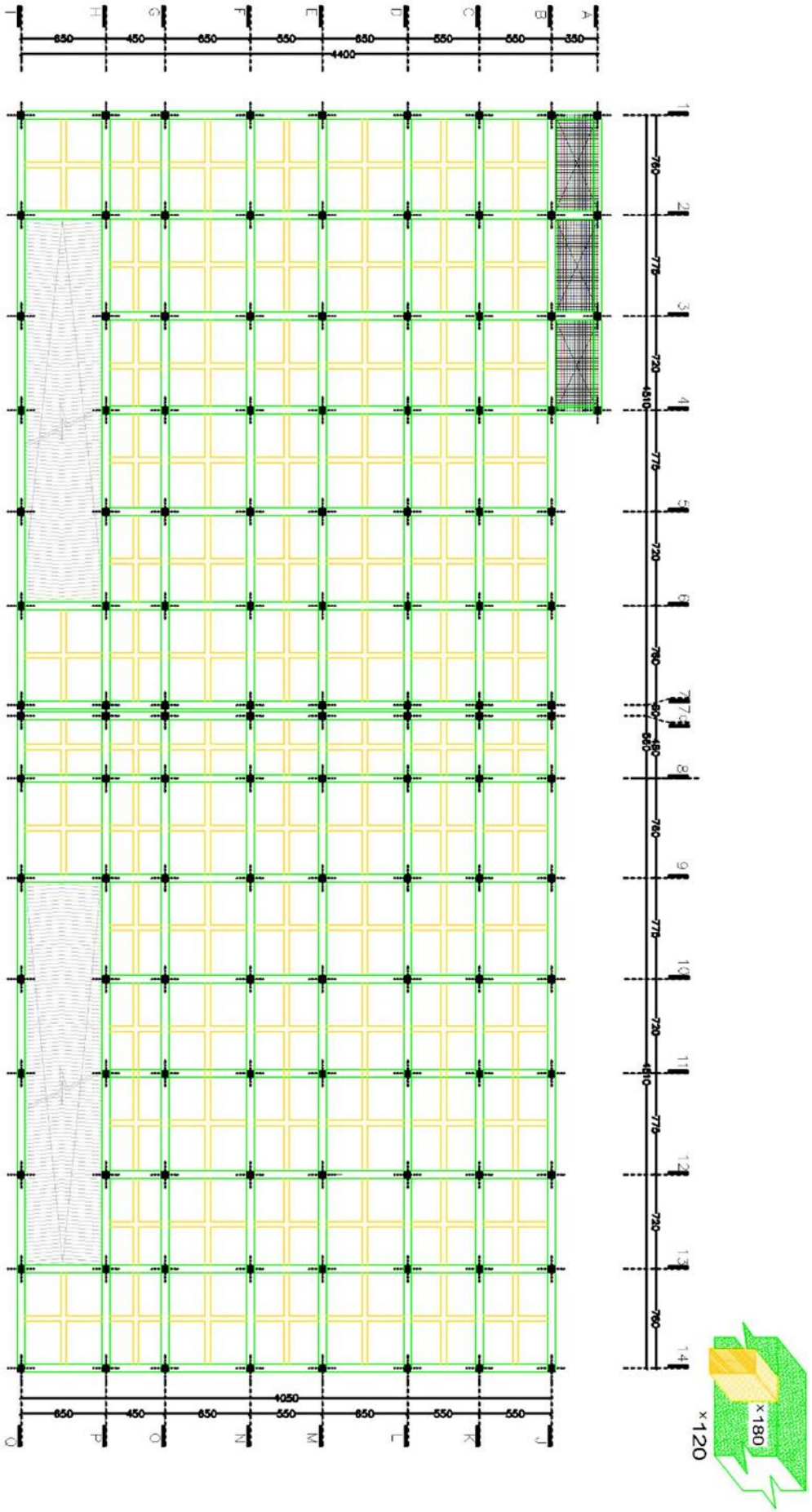


Figure 1.1. Beam and slab floor system

In order to control deflection for spans beyond 5 meters, it is required to practice 4-sided or 6-sided secondary beams between the main beams. Therefore, for spans as much as 5*6 and 7.5*6.5, 180 secondary beams by 45-cm-thick and more than 120 secondary beams by minimum 55-cm-thick must be applied for every floor.

On the contrary, due to the high rigidity in the Contruss voided slab system, gravity forces will be transferred directly on supports by drops, yet it creates a flat soffit (smooth bottom surface of ceiling), that will provide much advantages for the structure. Technical and economic properties of two systems will be compared to each other in the following.


650
450
650
550
850
550
550
350
4400
4050
4510
180
120

2- Technical and economic evaluation:

In this section, some technical and economic advantages of Contruss system will be illustrated in comparison to the beam and slab floor system:

2-1- Reduced ceiling thickness:

Large soffit (uneven bottom surface of the ceiling) in the beam and slab floor system will result in spending more costs for plastering, systems installation and project scheduling:

a) Increased total height of building due to reduced useful height of story

b) Increased cost and difficulty in formwork, concrete-pouring and reinforcement performance

c) Increased dropped ceiling cost

d) Architectural restrictions

e) Time-consuming construction compared to flat slabs

Figure 2.1. Contruss ceiling compared to beam and slab ceiling

2-2- Increased construction costs specially, for long span:

The Contruss voided slab has been come up to develop the conventional beam and slab system, based on the elimination of unloadable concrete in middle spaces with no structural benefit. The Contruss voided slab system weighs less compared to solid slabs, that will reach up to 60 percent with equal rigidity or minimum reduction in rigidity.

Due to high rigidity and low weight as well as two-way function, the voided slabs will be able to create large spans along with low ceiling thickness. For example, in a double-sided voided slab with 35-cm-thick, the concrete is poured in 22-cm height that will demonstrate optimized concrete consumption. Afterwards, a 22-cm-thick flat slab will provide a maximum 7-meters span, which express the voided slab advantages in providing of long span.

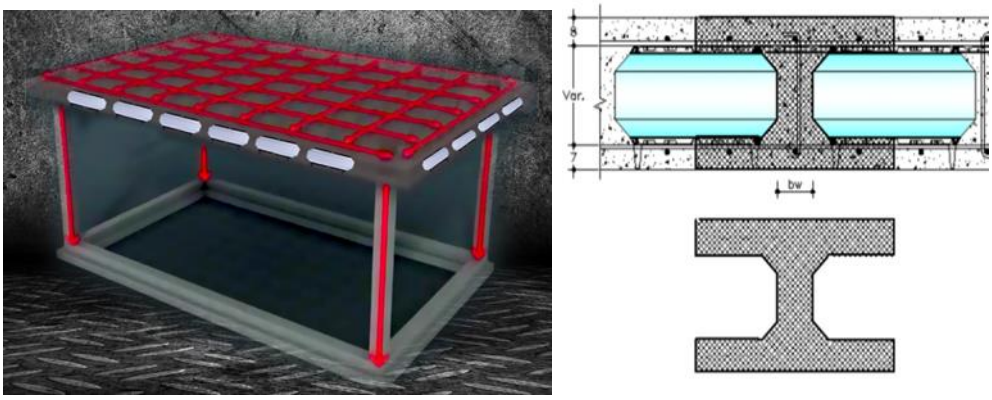


Figure 2.2. Schematic operation of Contruss voided slab

Similar to flat slabs, the Contruss system formwork will provide a flat intrados floor. Due to existence of beams and large soffit in the beam and slab floor system, dropped ceiling will be required which will increase construction duration and formwork costs.

2-3- Reduced consuming reinforcement bars:

Slab weight of the Contruss system is approximately equal to the beam and slab floor system. Although the Contruss voided slab has large thickness, but it will be acceptable and more practical with regard to removing middle columns, ribs and also creating a flat soffit. Furthermore, one important point in comparison of the systems is that bending capacity of Contruss voided slab is three times more than the beam and slab floor system with equal ceiling weight, which will result in considerable reduction in consuming flexure reinforcement in the voided slab. This difference in bending capacity will lead to reduction in the weight of consuming rebar in the Contruss system by as much as 15 percent compared to slab-beam system.

Therefore, due to the reduction in consuming rebar and cost of useless space because of flat soffit, total cost of Contruss system will be considerably less than slab-beam system.

For providing more parking lots, large spans between supports will be needed. Creating large spans is possible in the beam and slab floor system but it must be considered that ceiling deflection is controlled by the beams and ribs, due to low rigidity of the slab in this system. By increasing of span length, larger soffit will be created. For example, in a 12-meters- long span, minimum thickness of main beams and ribs will be as much as 60 and 50cm, that will result in increased cost of formwork, systems installation, facing and…

On the other hand, due to increased moment with a power of two in proportion to increased span length and non-increasing of ceiling bending capacity because of large soffit, the consuming reinforcement bars will be increased significantly in the slab-beam system which will lead to increased cost of consuming materials.

As a result, creating large span in slab-beam systems for gaining some advantages such as providing more parking lots, is not economical compared to the Contruss voided slab system, result in increased costs of materials and construction.

2-4- Enable to create large and irregular openings:

In the Contruss system, loads are transferred to supports through mutual I-shaped ribs but in the slab-beam system, gravity forces are transferred by the main and secondary beams, due to low rigidity of the slab. As regard to such transfer, creating unpredicted openings in ceiling for systems installation is not permissible in the slab-beam system, because of cutting beams and ribs. But in the Contruss system, existence of orthogonal I-shaped ribs will enable the slab to distribute rigidity on total surface of the ceiling; therefore, creating unpredicted openings in the ceiling will not disrupt function of the slab, due to redistribution of forces in around ribs.

Figure 2.3. Large opening in Contruss ceiling

Figure 2.4. Creating opening in Contruss slab

2-5 Simplified implementation:

The use of advanced technology in building construction requires spending much time and cost as well as protection and surveillance of the instruments. Meanwhile, the Contruss system is needed no special group for installation in spite of known as innovative engineering technology, that can be exerted easier than the beam and slab floor system. Positioning of upper and lower reinforcement bars, Contruss fillers and concrete-pouring are main steps to install Contruss voided slab system, which is capable of providing spans up to 20-meters in spite of simple installation.

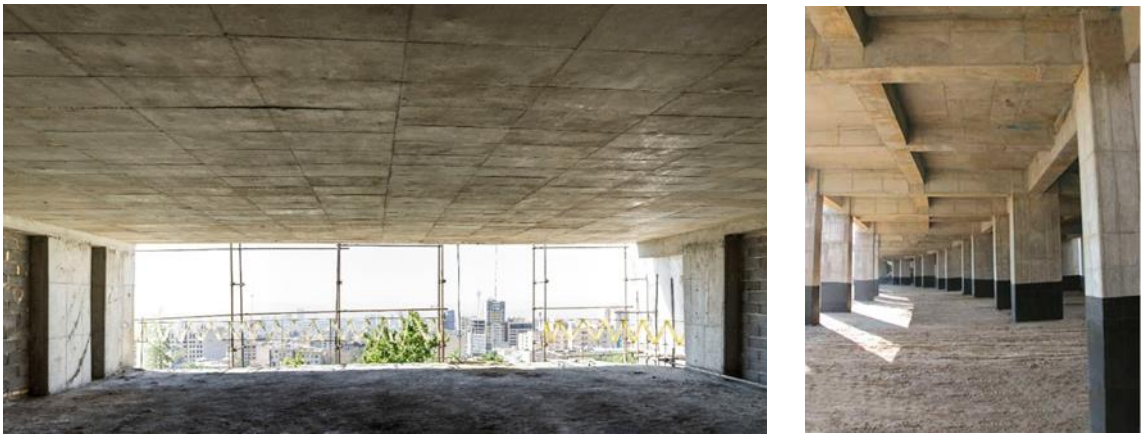


Figure 2.5. Simplified implementation of Contruss slab compared to slab-beam system

2-6- Construction speed:

By creating a flat soffit, smooth integrated formwork will be required for the Contruss system, result in easy and quick construction.

Figure 2.6. Installing Contruss voided slab

2-7- Fire resistance:

Concrete structures will endure better than steel structures in fire, generally. Due to existence of two concrete layers, the Contruss ceiling will function properly in transmission of heat when subjected to fire, provide more strength than the beam and slab floor systems. In addition, polystyrene used in the Contruss filler plays significant role in fire, avoiding heat from transferring between floors. It is a flame retardant material that sublimates steam and carbon dioxide subjected to fire. The Contruss filler has ignitability testing certificate by the road, housing and urban development research center.

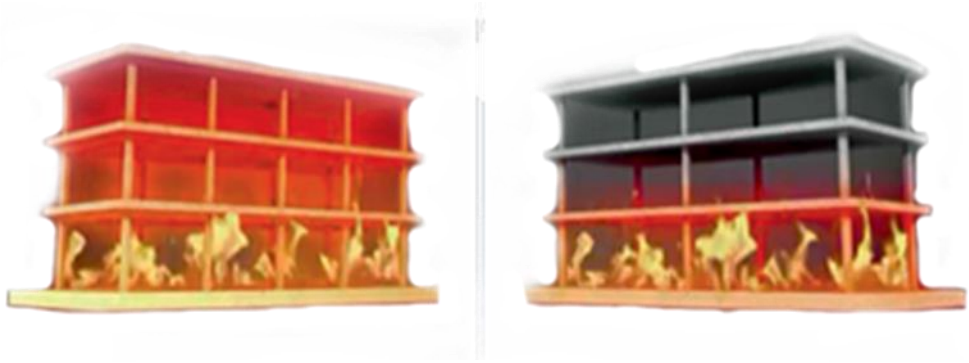


Figure 2.7. Heat transmission between floors in two systems

Ignitability testing certificate of Contruss filler:

Road, Housing and Urban Development Research Center

Fire engineering department

The conclusions of ignitability test on samples of flame retardant expanded polystyrene foam

Sample name: Contruss permanent filler core made of flame retardant expanded polystyrene foam	**Average thickness (mm):** 60.9	**Average density (kg/m^3):** 6.4

Sampling method	Sent by the applicant
Description of sub-layer	Without sub-layer
Deviation of test procedure	-
Description point of applied flame	Edge flame
Duration of applied flame	According to the attachment A

Observations	**1- The ignition:** No **2- Reaching top of flame up to 150 mm over point of applied flame:** No **3- The ignition of filter paper:** No **4- Physical behavior of sample:** contracted, melted

Concluding:

- The sample is a flame retardant type.

Road, Housing and Urban Development Research Center

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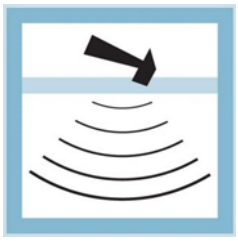
2-8- Resistance in transmission of noise and vibration:

Sound resistance of materials is investigated in two segments: 1) airborne noise, 2) percussion noise.



In general, the concrete ceilings operate properly in transmission of airborne noise, both Contruss and slab-beam ceiling system will not transfer airborne noise. However, difference is occurring in conjunction with percussion noise.

By involving trap air bubbles inside the polystyrene used in the Contruss system, sound power level is reduced by passing of percussion noise through the slab. Polystyrene is known as the second available materials that represents best acoustic function in sound transmission according to the building codes. Overall, applying polystyrene along with two concrete layers in the Contruss fillers have provided proper resistance subjected to airborne and percussion noise transmission.

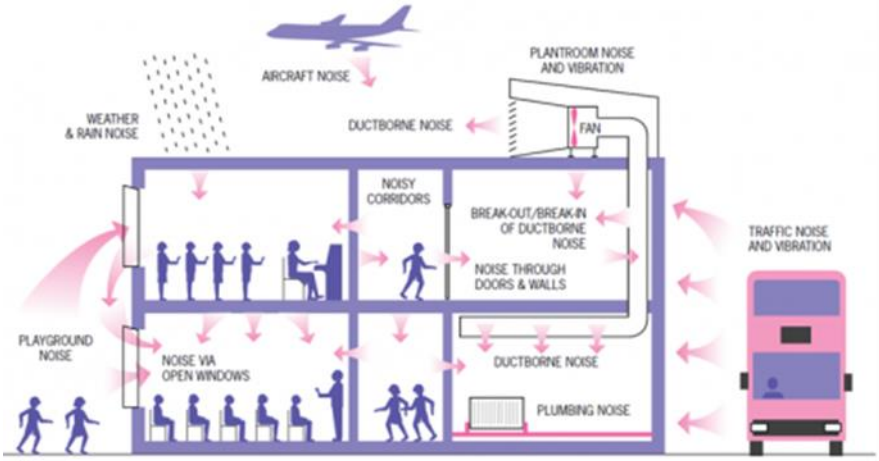


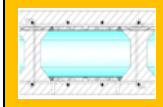
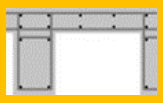
Figure 2.8. Schematic transmission of noise and vibration in building

In addition, due to the high rigidity of Contruss voided slab, it will transfer less ceiling vibration in comparison with the beam and slab floor system, that is a relief for the residents.

3- Conclusions and final comparison table:

- By including two upper and lower concrete layers, the Contruss voided slab ceiling forms a high rigid slab that will create a rigid diaphragm subjected to lateral forces and also provides possibility of creating large spans up to 20 meters, due to reduced slab weight.
- Due to the existence of large soffit and uneven bottom surface of ceiling in slab-beam system, formwork performance and implementation of this ceiling will accompanied by much cost and time.
- Because of cutting the beams as well as significant role of main and secondary beams in transferring of loads in slab-beam system, creating unpredicted opening is impossible in this system. Vice versa, it will be possible in the voided slabs because of equal rigidity all over the slab, existence of high degrees of freedom and redistribution of forces in around ribs.
- For spans beyond 7 meters, materials consumed in slab-beam system will be 15 percent more than Contruss system.
- Creating large span in slab-beam systems for gaining some advantages such as providing more parking lots, is not economical compared to the Contruss voided slab system, result in increased costs of materials and construction.
- Contruss ceiling will represent a flat intrados floor (smooth bottom surface of ceiling), but an uneven bottom surface of ceiling with large soffit will be created by slab-beam system. This difference will effect on useful height of each story, systems installation and sub-constructing of the ceiling.
- The Contruss system provides more benefit in terms of functional specifications such as resistance in fire, vibration and noise transmission.
- From scientific viewpoint, the Contruss system is an innovative modern system compared to the slab-beam system.

In the following table, the specifications of two systems are compared to each other:

	Contruss voided slab system 	Slab-beam system 
Adapt to large spans and cantilevers	★★★★★	★★★★
Resistant in sound transmission	★★★★½	★★★
No need for dropped ceiling	★★★★½	★★
Construction speed	★★★★	★★½
Simplified implementation	★★★½	★★★½
Lack of large soffit and drops	★★★★½	½
Fire resistance	★★★★★	★★★★
Construction costs for spans beneath 8-meters	★★	★★★½
Construction costs for spans beyond 8-meters	★★★★★	★★½
Reduced vibration and deflection	★★★★★	★★
Reduced weight of structure	★★½	★★★
No need for special parties to install	★★★★½	★★★★½
Adapt to irregular large spans	★★★★★	★★
Adapt to irregular supports	★★★★★	★★½

Complete points: ★★★★★