Contruss
Engineering Company

Comparison of ConTruss voided slab with Metal deck 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, metal deck system will be illustrated and compared to the Contruss voided slab system, from technical and economic point of views.

1- Metal deck system introduction

Metal deck system is a method practiced for constructing of ceiling in steel and concrete structures, that was first used by beading of galvanized steel sheets by Henry Palmer in 1820. This ceiling system has been entered in constructions since 1939, after publishing a standard for designing and constructing by Steel Deck Institute. After various changing in construction manner of metal deck ceiling, finally it was practiced as a modern system containing numerous advantages by valid American and European companies in 1980.

The components of metal deck ceiling:

a) Steel sheet

b) Stud shear connector

c) rebar

d) concrete

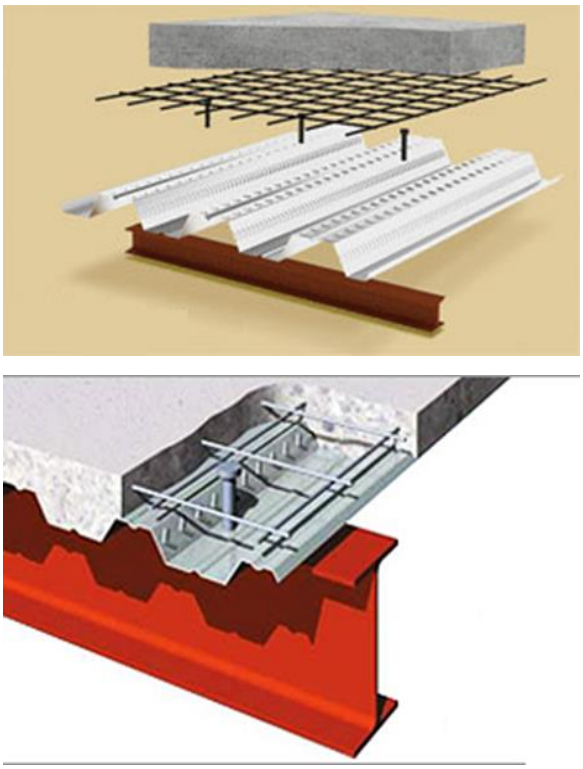

Figure 1.1. components of metal deck system

2- Technical and economic evaluation of metal deck system

2-1- Cost:

In general, steel structures construction will cost much higher than concrete structures, while applying metal deck will increase the costs. The construction of metal deck system will cost 20 to 50 percent more than the Contruss system. This considerable difference along with other advantages by concrete structures has led to increase of global tendency to this system.

2-2- Construction speed:

Although steel structures are capable of being constructed as much as 30 percent quicker than concrete structures, but there are two subjects to be considered:

1) By constructing concrete structures over two times per day as a so-called Fast-track project, it will be completed quicker than the steel structures and at the same time it is more economical even by two times working per day.

2) After constructing a few bottom stories in tall concrete structures, it is allowed to begin the brickworks and systems installation in mentioned stories and keeping formwork in upper stories simultaneously, that will make construction speed of concrete structures equal to steel structures.

Figure 2.1. Comparison of Contruss with metal deck

2-3- Simplified implementation:

Steel structures are capable of welding but major difficulties will be created by any possible fault in welding of the connections, due to the importance of connections in earthquake.

Figure 2.2. Welding fracture in steel structure

There are also some difficulties in concrete structures during concrete-pouring; the main possible problem is creating of honeycombs concrete in the connections.

Figure 2.3. Honeycombing in concrete in the connection of column and diaphragm

The most difficulties in construction of concrete structures are related to specifications of consuming concrete; however, by developing of admixtures such as accelerators, improvement of concrete specifications will be possible with low cost. For example, there are several natural and artificial admixtures that will improve many properties of concrete such as strength, durability, slump and workability. This quality is not existed in steel.

The price of such admixtures are very insignificant in comparison with cost of consuming concrete or structure, that will cost less than 1 percent of structure costs. For example, adding of accelerator in consuming concrete increases workability of concrete that will avoid from creating honeycombs sections as well as increasing concrete strength.

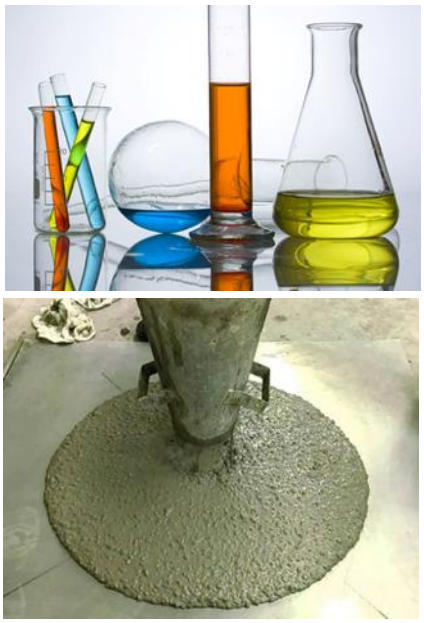

Figure 2.4. Concrete structures

The other difficulties and problems related to constructing of steel structures are: providing safety for welders, inspecting of connections, non-threaded of bolts, inability to stainless of some steel plates and…

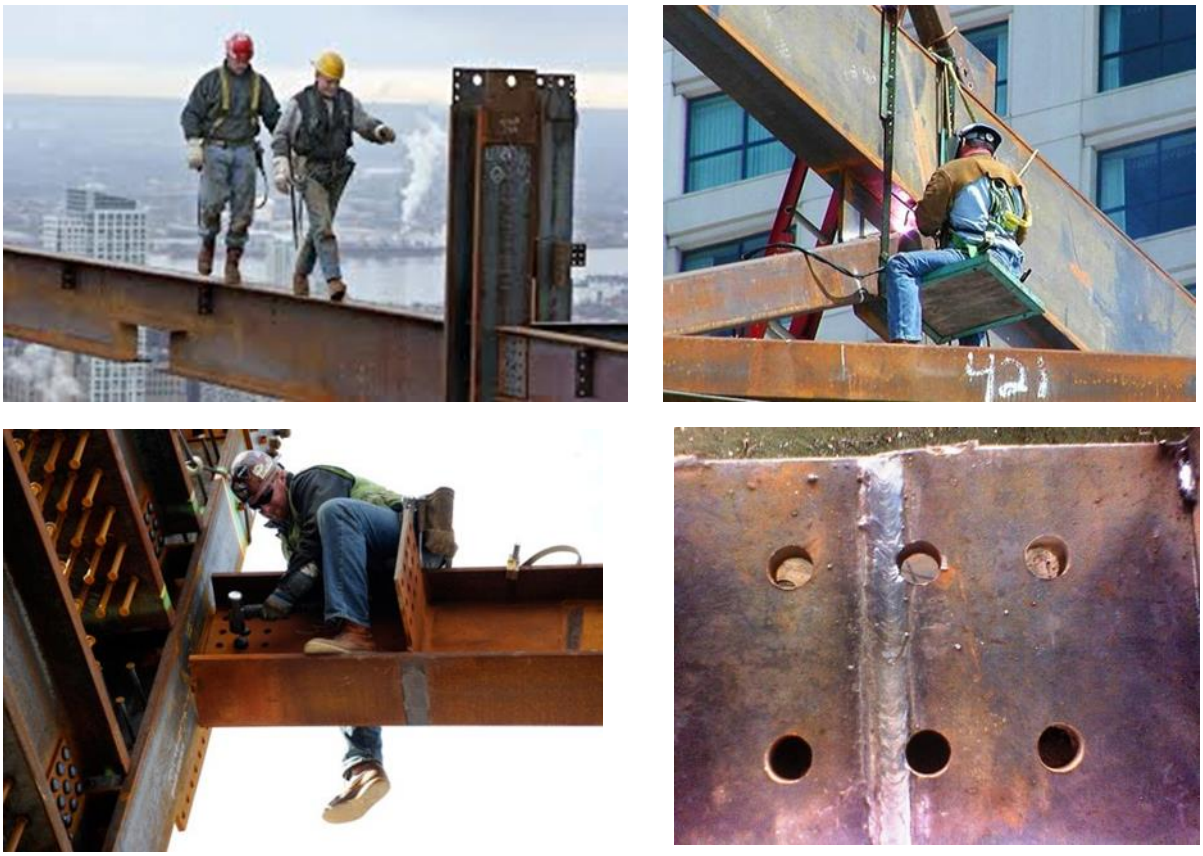

Figure 2.5. difficulties in constructing of steel structures

From constructional point of view, metal deck ceiling will be completed quicker because of quick installation of steel sheets as well as no need for integrated formwork of ceiling, but this increase in performance speed will require much cost.

The Contruss system is a modern technology that will be capable of simple installation by conventional workers after simple training.

Figure 2.6. Installing the Contruss fillers on site

Figure 2.7. Installing stud shear in metal deck

2-4- Durability:

Due to the corrosion of steel, special measures must be considered for protection of steel structures. Using of stainless in total structure is impossible; for example, between the plates in bolted connections structure. In concrete structures, the strength will be increased because of composing regular silicate structures; however, it might be reduced after a while because of creep in concrete. By considering suitable technical measures, exploitation period of concrete structures will be increased and that's the reason of constructed tall tower all over the world by concrete system in 20th century.

Figure 2.8. Corrosion of steel in different environmental conditions

2-5- Architecture:

Small dimensions of columns is a main advantage of steel structure, but by using the Contruss system, span length will be increased and middle columns can be removed, leads to more architectural freedom. On the other side, curved beams will be constructed simply by Contruss system; this benefit is not included in steel structures. Providing large span will be accompanied by several advantages such as better aesthetic, increased number of parking lots, partitions displacement and architectural freedom.

Metal deck system can be installed simply for spans up to 8 meters, but by increasing span length, it will cost much as well as increased ceiling thickness; so it is not known as an economical system in structures included large spans. By inclusion of two concrete layers along with perpendicular webs, the Contruss ceiling form a high rigid slab that will provide a rigid diaphragm subjected to lateral forces as well as provide spans up to 20-meters long.

Figure 2.9

Figure 2.10. Large span provided in Contruss system

2-6- Fire resistance:

Inadequate strength subjected to fire is mentioned as one of the major defects of steel structures compared to concrete structures. The strength of steel structures in temperature of 600°c will be reduced to half, but concrete structures will operate more properly in fire.

Figure 2.11. Collapsing of a steel structure in fire

For protection in fire, use of fire proofing materials is proposed by the valid codes, but these materials will cost so much.

Figure 2.12. Thermal insulation in steel columns

Concrete ceilings operate more properly subjected to fire; therefore, operating in fire is a weakness related to metal deck system. Due to the existence of two concrete layers, the Contruss ceiling will function properly in transmission of heat when subjected to fire, offer much more strength than metal deck system. The polystyrene used in the Contruss filler has been certified that is a flame retardant type. The fire test certification is presented in the following.

Figure 2.13

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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.

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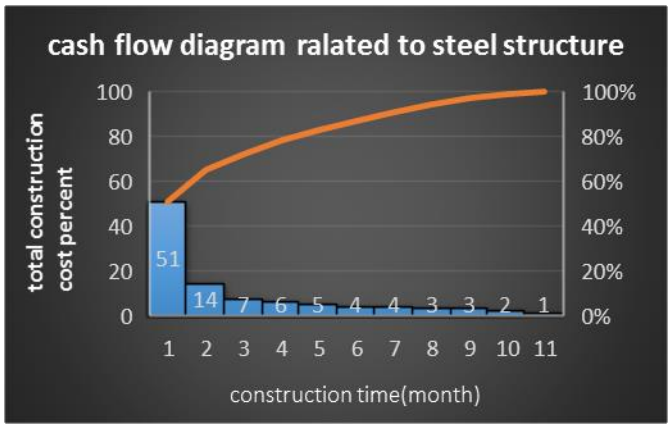
Figure 2.14. Fire test certification

2-7- Cash flow:

The major issue considered as a distinction between the Contruss and metal deck system is referred to financial subject. In general, steel structures construction will cost much higher than concrete structures by 35 to 50 percent.

Moreover, concrete structure will offer a better opportunity for builders, who are willing to spend for construction step-by-step, as regard to project progress. Because of using metals in steel structures, it is required to spend much cash at the beginning of project.



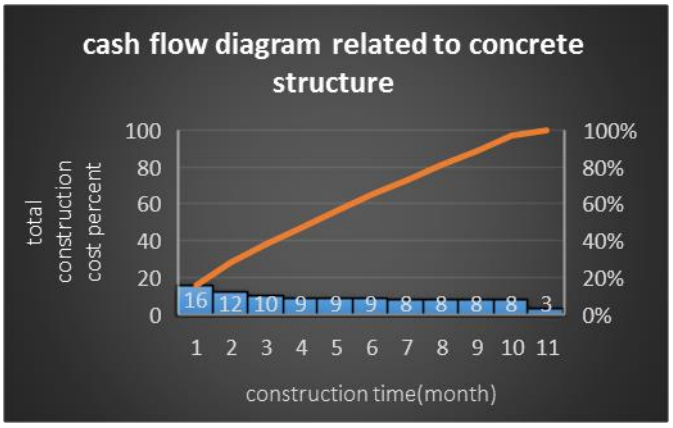


Diagram 2.1. Cash flows related to steel and concrete structures

2-8- Adapt to openings:

As a one-way system, cutting ribs will disrupt load transfer, that will make it so difficult to create openings in metal deck system. Therefore, necessary measures must be considered to create openings in this system. Additionally, in order to create openings (for passage of systems) after slab installation, the decking must be slashed initially as well as reinforcing cutting beams, then the ceiling is ready for creating opening.

According to the high rigidity as well as two-way function, the Contruss system is capable of creating large irregular openings in the rigid diaphragm, which matters much in reception halls, villas, commercial and educational centers. Also, creating additional openings for passage of systems will be possible even after completion of slab installation.

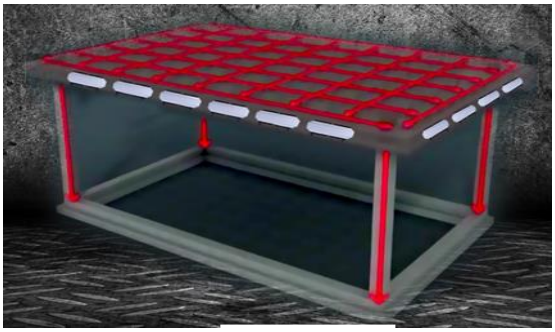


Figure 2.15

Figure 2.16. Ceiling constructed by Contruss voided slab

2-9- Increased ceiling thickness:

Drops and large soffit will be accompanied by following problems:

Figure 2.17. Large soffit in metal deck

1- Increased total height of building because of increased height of each floor

2- Increased cost and difficulties in framework, systems installation, plastering and…

Figure 2.18. Required to install sub construction in metal deck

3- Increased cost of dropped ceiling

4- Architectural restrictions

5- difficulties in passage of systems

By providing shear walls, the Contruss system formwork will be performed continuously, that result in creating a flat soffit. This advantage will resolve all of the mentioned defects related to metal deck system.

Due to the one-way function of metal deck system, thick girders and large soffit will be created. By constructing dropped ceiling as well as large soffit and thick girders, useful height of floors will be reduced. For spans more than 10 meters, the Contruss system will come up with a lower total thickness of ceiling.

Moreover, passage of systems over girders will result in deeper dropped ceiling as well as reduced useful height.

In the Contruss system, total thickness of ceiling will be reduced. For example, ceiling thickness for a 12-meters-long span will be 35 cm, but a flat surface is created under of ceiling that can be simply used for systems installation as well as plastering. Reduced total height of building by the Contruss system will result in increased number of floors as well as much savings.

Figure 2.19. Flat surface of Contruss ceiling

2-10- Acoustic function in transmission of noise:

Sound insulating 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; once by involving polystyrene, acoustic function in percussion noise will be improved. As a result, the Contruss slab will function more properly than metal deck when subjected to both airborne and percussion noise.

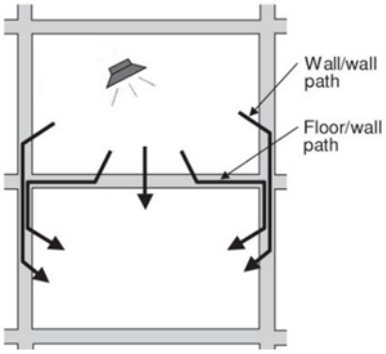


Figure 2.20. Acoustic behavior of ceiling

2-11- Ceiling weight:

The Contruss voided slab weighs more than metal deck which will be acceptable by considering lower costs, adapt to large spans, less ceiling thickness in large spans, high rigidity and the other superior related to the Contruss system.

2-12- Resistance subjected to vibration:

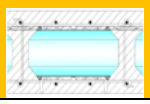
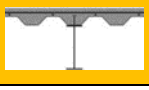
Resisting in transmission of vibration regarded to ceiling is known as one of the most essential property for the residents. Providing such resistance will cost much in steel structures. On the contrary, due to the high rigidity of Contruss voided slab, it will operate more properly subjected to vibration, which is a relief for residents.

Figure 2.21. Non-transferable floor in Contruss system

3- Conclusions and final comparison table

- The construction cost of metal deck system is definitely more than the Contruss system; this difference will be 20 to 50 percent of total construction cost.
- For spans more than 8-meters-long, the mentioned difference will be increased even by more than 50 percent.
- By the use of Contruss system, a flat intrados floor will be created; vice versa in metal deck system, an uneven surface ceiling will be created.
- In terms of weight considerations and construction speed, metal deck system is privileged, but there will be some difficulties in durability and installation.
- 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 metal deck.
- On the contrary to the Contruss slab, metal deck is a one-way system, which will cause some restrictions for the ceiling such as inability to adapt to openings.

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

	Contruss 	Metal deck 
Adapt to large spans and cantilevers	★★★★★	★★★
Resistant in sound transmission	★★★★½	★½
No need for dropped ceiling	★★★★½	½
Construction speed	★★★★	★★★★★
Simplified implementation	★★★½	★★★★
Lack of large soffit and drops	★★★★½	★★½
Fire resistance	★★★★★	★
Construction costs for spans beneath 8-meters	★★	★
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	★★★★
Adapt to irregular large spans	★★★★★	★★
Adapt to irregular supports	★★★★★	★★★

Complete points: ★★★★★