Comparison of ConTruss voided slab with Prestressed system

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

1- Prestressed system introduction

1-1- Prestressed system history:

Based on the concept of compressing the tensile face of concrete as well as optimizing section, prestressed system has entered in constructions since 1950. Due to the complicated implementation, much research has been done on the consuming concrete and cables practiced in this system. The use of high-strength concrete, high-tech and expensive cables and specialized installation method are some properties related to this system. Today, this system is practiced extensively in bridges and long span up to 400 meters.

1-2- Components of ceiling:

The use of high-strength cables under tension is unique specification of prestressed system compared to other concrete system.

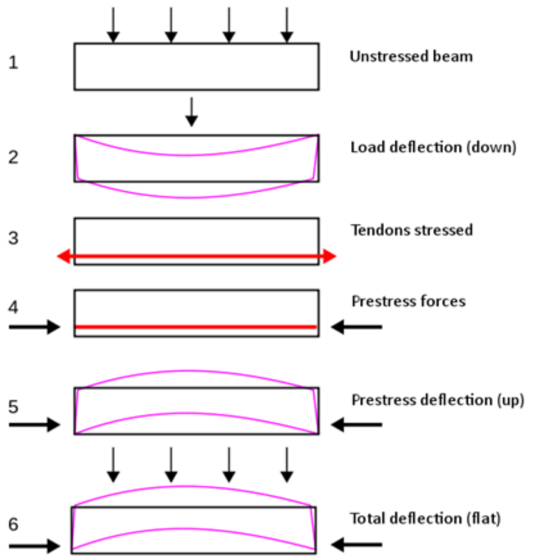

Figure 1.1. Schematic operation of prestressed system

Figure 1.2. Pre-tensioning of prestressed system

1-3- Implementation methods:

- Prestressed system
  - Post-tensioned
    - Bonded
    - Unbonded
  - Pre-tensioned

Pre-tensioned systems are usually practiced in industrial structures, while post-tensioned systems are more practical in buildings.

2- Technical and economic evaluation

2-1- Required advanced technology:

The use of advanced technology in building construction requires spending much time and cost as well as protecting of instruments during construction. As regard to scientific and technical complexity, the prestressed system is accompanied by several difficulties which will discourage the builders to use unless for bridges.

Figure 2.1. Positioning of strands

One example about complexity of the prestressed system is releasing of post-tensioning cables under tension, which is required to be inspected after a while but the inspection is not viable in buildings.

Figure 2.2. Releasing of strands

Another example about complexity of the prestressed system is occurred when opening is needed after slab installation. None of the cables must be teared after slab installation. In addition, the cables must be always protected, because major parts of applied loads are borne by these cables.

Figure 2.3. Prestressed system in bridge

Positioning of cable pods according to the curvature of scheme is another difficulty in the prestressed system installation, which is required specialist parties to position, tension and cover the cables.

On the contrary, installing the Contruss ceiling is followed by positioning of the fillers, lower and upper rebar and concrete pouring, that is as simple as conventional ceiling system but it is capable of providing large spans up to 20 meters.

Figure 2.4. Contruss system installation

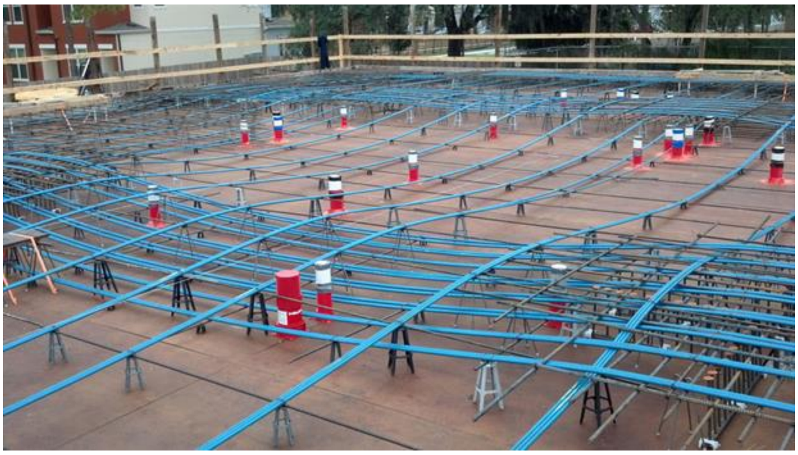

Figure 2.5. Prestressed system installation

2-2- Construction speed:

Based on the following reasons, the prestressed system will require more time to complete than the Contruss system:

1- concrete must be hardened before pre-tensioning:

Concrete is required to be hardened before applying the pre-tensioning force in the post-tensioned system, so the executive party has to complete the process after hardening. Then the formworks are removed to apply for next ceiling.

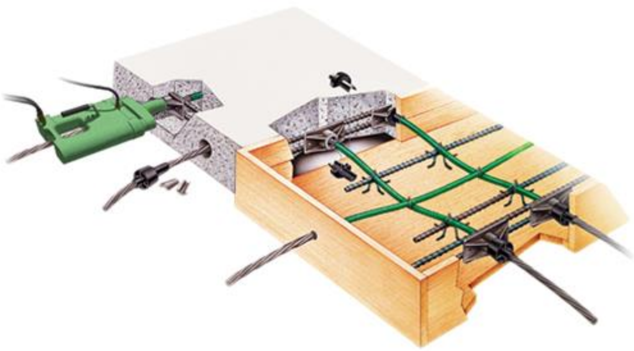

Figure 2.6. Schematic section of prestressed slab

2- In many prestressed slabs, in addition of integrated ceiling formwork, drops and large soffit (uneven bottom surface of ceiling because of thick beams) formwork is needed which will increase the construction duration and costs.

Figure 2.7. Prestressed system applied in building

3- Because of involving specialist parties, delay in presence of one special group will increase total construction duration.

2-3- Cost:

The amount of consuming concrete and rebar are approximately equal in both systems but the Contruss system will cost less by 5 to 10 percent, due to simple installation as well as lower cost of Contruss filler.

2-4- Existence of drops and large soffit in most of prestressed ceilings:

By the use of compressive strength of concrete, prestressed system tries to come up with a lower slab thickness but the section will not operate properly subjected to shear usually, due to the accumulation of shear forces in the connection zone of ceiling and columns. As a result, due to inadequate slab thickness, existence of drops under of ceiling will be required in order to control shear punch. In addition of drops, large soffit is required in the prestressed system. Large soffit and drops are known as important elements in construction, from architectural and economic point of views.

There will be more difficulties related to the prestressed ceilings constructed by pre-tensioning method such as creating flaw in the ceiling, architectural restrictions and installation problems. By regarding of such difficulties as well as increasing of costs, pre-tensioning method is usually applied for industrial ceilings.

Figure 2.8. A prestressed ceiling system

2-5- Strength subjected to noise transmission:

Material resistance in sound transmission is investigated in two segments: 1) airborne noise, 2) percussion noise.

In general, the concrete ceilings resist properly in transmission of airborne noise; but by practicing of polystyrene, the ceiling strength in transmission of percussion noise will be increased. Therefore, the Contruss slab will operate more properly than the prestressed ceiling in noise transmission. Furthermore, with regard to the increased rigidity of Contruss voided slab, it will transfer less ceiling vibration in comparison with the prestressed system, that is a relief for the residents.

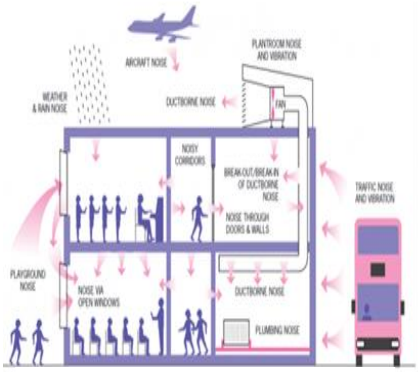

Figure 2.9. Noise and vibration transmission

2-6- Adapt to openings:

Because of disrupting the cables trajectory, it is so difficult to create openings in the prestressed slab system, and also impossible to implement special formed openings in many cases.

In the Contruss system however, creating large irregular openings in ceilings will be so simple, which matters much in reception halls, villas and commercial and educational centers.

Figure 2.10. Created opening in the Contruss voided slab

2-7- Fire resistance:

Due to the existence of two concrete layers along with a flame retardant polystyrene between them, the Contruss ceiling will function properly in transmission of heat when subjected to fire, provide more strength than the prestressed ceiling systems. The polystyrene used in the Contruss filler has been certified that is a flame retardant material.

The major defect related to the prestressed ceiling when subjected to fire is releasing of the post-tensioning cables. As regard to providing much resistance for total strength of the slab by the cable, it will be expanded and fail in fire that leads to collapse of the ceiling.

The ignitability testing certificate of Contruss filler is in the following.

Road, Housing and Urban Development Research Center - Fire engineering department

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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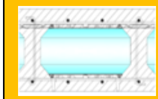
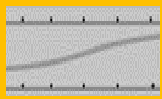
3- Conclusions and final comparison table:

- For spans beyond 7 meters, applying innovative systems is more practical than the conventional slab-beam system.
- Prestressed system requires high-tech and special instruments to install although it is capable of providing spans beyond 30 meters for bridges and wharfs.
- The Contruss system will not require advanced instruments to install, even though known as an innovative technology.
- The Contruss system will cost and weigh less than the prestressed system.
- The Contruss system provides more benefit in terms of functional specifications such as resistance in fire, vibration and noise transmission.

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

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

Complete points: ★★★★★