Ghafooripour et al., J Steel Struct Constr 2019, 5:1

Journal of Steel Structures & Construction

Research Article

Open Access

Flooring Systems with Prestressed Steel Stringers for Cost Benefit

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Abstract

Of the existing flooring system types, steel flooring systems are often times overlooked due to their material cost. However, this problem can be addressed by prestressing steel and reducing the weight of each element. Through a three-part analysis, this research concludes that using prestressed steel for flooring systems, when in an optimal configuration, is economically viable. The first part focuses on tests to determine an optimal stringer shape for the flooring system between I-beams and trusses. Once it was determined that truss stringers required less steel for their span, stage two focused on finding an appropriate tendon profile with the goal of cost reduction in mind. The final stage used a comparative cost analysis to ensure that the flooring system with the stringer shape and prestressing tendon profile selected in the previous steps were economically beneficial to those who might choose to adopt this method. The results show that the prestressed truss with straight tendons has maximum efficiency.

Keywords: Prestressed steel; Prestressed truss; Prestressed beam; Cost-benefit

Introduction

Prestressing techniques for steel beams were developed many years ago, both for the construction of new structures and for the rehabilitation of existing structures. A number of prestressed steel structures in the following years have been built throughout the world, especially in the USA, Russia, and Germany, which demonstrates that prestressed steel beams can present both structural and economic advantages when compared with non-prestressed (traditional) beams. However, the prestressed steel technique has been adopted mainly for bridges and rarely for the floor/roof structures [1].

Prestressing is the process of artificially creating stresses that would oppose the stresses later applied by a load [2,3]. The two loads, prestressed and regular, increase the elastic work of the material. On the other hand, the basics of prestressing lie in the fact that the stresses are developed artificially which are opposite to those stresses created due to loading [4,5]. When a prestressing load f0 is induced in a structure which inverses stress due to the action of the loading, this stretches the elastic work of the material (Figure 1).

For example, a bar with an allowable stress value of F can endure both prestress and the stresses from a load. The same bar has an even larger load-carrying capacity but remains within value F, when a multi-step or cyclical prestressing is applied. The result is a uniform distribution of stress in the material, ensuring effective use [6-9].

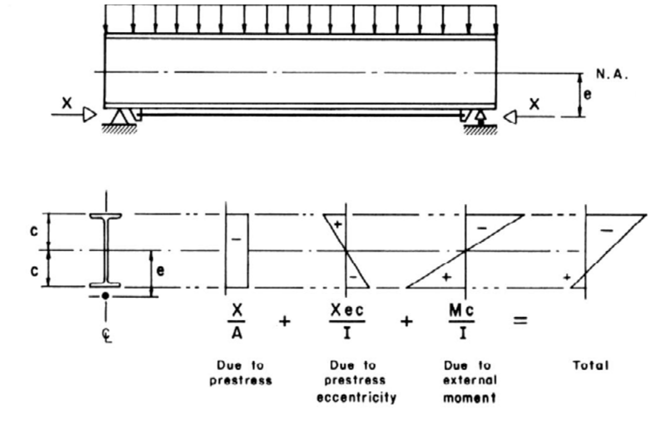

Figure 1: The stress distribution due to prestress and load on a symmetrical steel I-beam.

According to Subcommittee 3 on Prestressed Steel of the Joint ASCE-AASHTO Committee on Steel Flexural Members, there are three main prestressing methods for steel beams [10-15].

Method 1: Prestressing by using tendons along the beam, the concept is to place steel strands or high-strength steel cables as far as possible from the neutral axis at the tensile region of the section [16-18]. There are two ways of prestressing the steel beams using high-strength tendons or cables. One way is to place them below the center of gravity of the beam and fix them to the beam at its end. This results in constant prestress. The second method is by draping the tendons along the length of the beam (Figure 2).

Method 2: The pre-deflected beam method or Preflex the beam by deflecting it downward, cambering it upward with a concrete slab, and jacking the beam downward again.

Method 3: Apply tension to and then weld high strength steel plates in the tension zone

The formation of the prestressed steel structures starts in 1907 when Koenen suggested the use of prestressing steel bars before applying concrete for eliminating the formation of cracks and thus discovered Reinforced Concrete (RC). Since the phenomenon of shrinkage was not known at that time, his attempts were not successful [19,20]. In 1950 Coff L was granted US Patent on a prestressed composite beam

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Received February 10, 2019; **Accepted** February 20, 2019; **Published** February 25, 2019

Citation: Ghafooripour A, Nidhi A, Barreto R, Rivera A (2019) Flooring Systems with Prestressed Steel Stringers for Cost Benefit. J Steel Struct Constr 5: 150.

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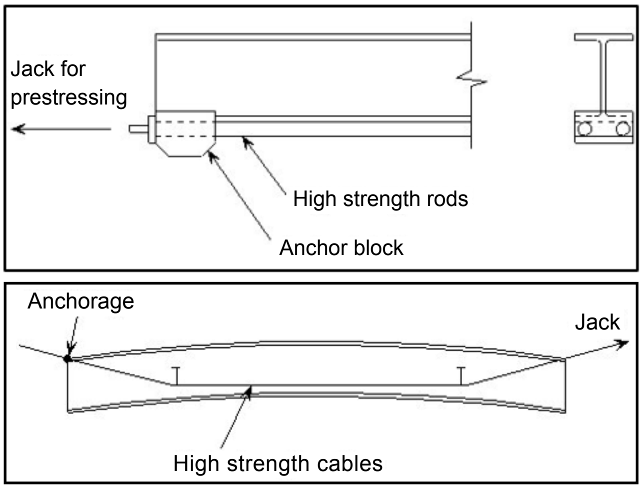

Figure 2: Prestressed beam with tendons.

of beam and steel. Jenkins investigated the possibility of prestressing lattice roof trusses by means of a cable passing below the structure and Belenya Published “Prestressed load-bearing metal structures” in 1977 [1]. Troitsky et al. presented a detailed static analysis of continuous steel girders prestressed by high-strength steel cables [8]. His research reflects that a reduction in the negative bending moment results at the intermediate supports due to the influence of prestressing. The decrease in the negative bending moment differs with the number of spans, span lengths, sectional properties, etc. When compared to the continuous girders without prestressing, it is observed that there is a decrease of up to 20% in negative bending moments at the intermediate supports of the three-span girders [8].

Shushkewich determined the equivalent loads of prestressing, developed a set of equations [18]. Zielinski [19] investigated the behavior of a slender steel pipe with prestressing force. The author concluded that a steel pipe with an internally placed tendon is not subject to buckling during stress and deflection of the pipe [19]. Gupta et al. suggested using the concept of Vlasov’s circle of stability under eccentric prestressing force, and they explained that limiting the ratio of the depth of web to span equal to 10 and placing the tendon below the bottom flange requires a large critical force for torsional buckling [12]. Gupta et al. [13] studied the effect of different parameters such as the ratio of web height to web thickness, percentage web area to total area, and location of tendon and self-stressing factors for the beam on allowable uniform load for monosymmetric I section. This study also provides ready-to-use tables showing the alternative section to Indian standard rolled steel beam and provides the maximum permissible height and prestressing force for a given uniform load and span condition [13]. Murthy et al. [20] outlined the theory and design process of prestressed elastic and prestressed plastic methods for simply supported and continuous beams, and they concluded that the prestressed plastic design option is more advantageous than the prestressed elastic option [20]. Ronghe et al. [10] analytically and experimentally studied the effect of various tendon configurations and prestressing parameters of analysis and design of steel plate girders [10,11]. Also, they analytically examined the effect of various tendon configurations such as straight, V-shaped, and trapezoidal tendons and prestressing parameters such as eccentricity, prestressing force, and the ratio of prestressing span to full span on the load-carrying capacity of prestressed plate girders by considering the self-stressing force effect [9].

Albrecht et al. [15] explored the possibility for the design of prestressing tendons concentric with members for strengthening steel truss bridges and Belletti et al. [16] examined the behavior of steel beams with the focus on the two parameters, i.e., the number of deviators and the value of the prestressing force. Wadee et al. [14] studied prestressed stayed columns with a single cross-arm system and suggested general design procedures for the same . Ghafooripour [4] proposed a method for prestressing of the steel cold form trusses to reduce the weight of the steel . Also, in another research Ghafooripour [2] studied the effect of the form the form of the structure on the prestressing losses .

After a review of recent literature on prestressing, there is a noticeable lack of investigation into using prestressed floors for commercial and residential use. Thus, this paper attempts to study not only prestressed I-beam and truss flooring components but also their optimal configuration. Contents are subdivided into a few sections: Stage 1 Determining optimal stringer shape focuses on tests to determine an optimal stringer shape for the flooring system between frames with I-beams and truss bents; Stage 2 Optimizing tendon profile for truss frame; Stage 3 Cost-Benefit Analysis, and a conclusion that discusses the results for all stages.

Numerical Modeling

To investigate the proposed system, 2D models of one steel frame are modeled using STAAD Pro 2007. The floor stringers under investigation are I section and truss. For each case, frames with different spans are modeled varying from 5 to 30 m. The height of the frame remains constant as 4 m in order to have enough headroom in the building. For each Span, STAAD models are prepared for different prestressed loads starting from 0 applied at an interval of 100 KN. This exercise provides the optimum span for using a prestressed stringer for both the cases.

Further, the results for both the frames are compared to determine the most optimum stringer shape for the prestressed flooring system. The next step is to examine this optimum stringer shape with different tendon profiles-straight, curved and V-shaped. This is done to obtain a more optimized configuration of the stringer. Effective Length for all the members as per BS5950:part1:2000 Tables 1 and 2.

The first flooring system used to test the prestressed steel stringers is composed of single bay steel frames at an interval of 5 m each. These flat steel frames remain at a constant height of 4 m, with concrete slab placed on top. Pinned supports base plates are used throughout all frames to maintain a lighter foundation. For I section frames, haunch is provided at the two ends of the beam varying from 200 mm to 500 mm as required. The length of haunch is taken as 10% of the span as standard practice (Figure 3).

The second system used is the steel truss bent with the same dimensions and fixed support connection to the foundation (Figure 4). For the truss frames, the span-to-depth ratio is 15 for all truss models.

Since there are two different proposed systems are investigated, two different finite element models were made using STAAD Pro 2007 with the expected limitations mentioned in Table 1.

Material Description

All the sections used in the frame are standard hot rolled section as per BS 4-1:2005. For I-section frames universal beams are used. For truss, pipes are used. Table 2 describes the material of the frame and the prestressed tendon.

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Horizontal Members	Length to calculate slenderness ratio for buckling about local (major) z-axis	0.7 times span
	Length to calculate slenderness ratio for buckling about local y-axis	1.5 m with secondary members placed every1.5 m
	Unsupported Length	1.5 m with secondary members placed every1.5 m
Vertical Members	Length to calculate slenderness ratio for buckling about local (major) z-axis	1.5 times length of column
	Length to calculate slenderness ratio for buckling about local y-axis	0.85 times length of column
	Unsupported length	0.85 times length of column

Table 1: Effective length of structural members [5,7].

Material	Name	Young's Modulus	Poisson's Ratio	Density (kg/m³)	The coefficient of thermal expansion	Use
1	STEEL	205.00	0.300	7.83E+3	12E-6	Frames
2	High Strength Steel	195.000	0.300	7.83E+3	12E-6	Prestressed Tendons

Table 2: Material properties.

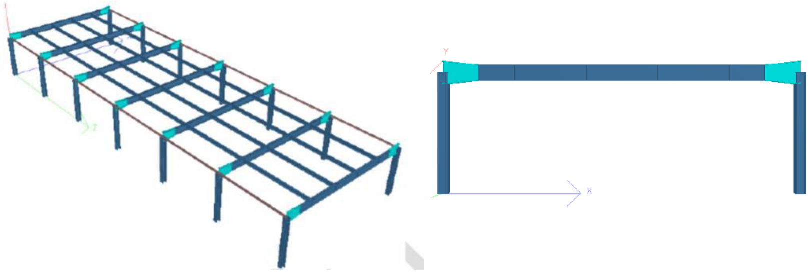

Figure 3: 3D model of flooring system with I-beam stringer.

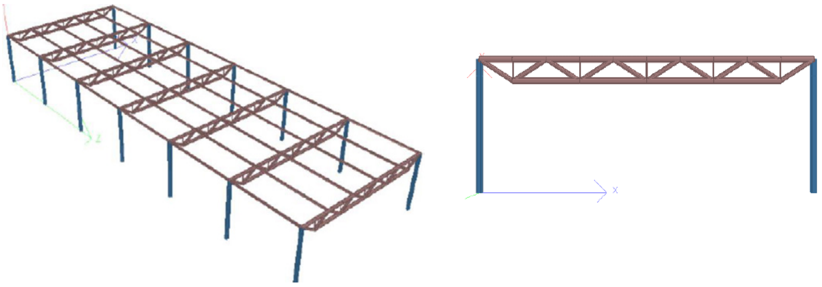

Figure 4: 3D model of flooring system with truss stringer.

Load Combinations

Two load combinations are considered for this investigation:

Dead Load + Prestressing Load

Dead Load + Prestressing Load + Live Load

The loads are applied as uniformly distributed line load on the horizontal frame member. Two different load applications were used to analyze the prestressed stringers. The first load, which will be referred to collectively as the dead load, includes:

- Frame weight, calculated by the software
- Concrete flooring weight, estimated at 25 kN/m for a 200 mm thickness
- Weight of any finishes, estimated at 10kN/m

The second load type includes the dead load plus a 10kN/m live load.

Software and Modeling Verification by Experimental data

Ronghe et al. experimented with a prototype model of a prestressed steel testing frame with a straight tendon in the Laboratory for its safe load carrying capacity and maximum deflection [10,11]. To verify the finite element model, the results from this experiment are compared with the STAAD results for the same model.

Experiment data

A prototype model of prestressed steel testing frame (Figure 5) (dimensions: length 4310 mm, width 1830 mm and height 1850 mm, all members ISMB300) with straight tendon for entire span has been designed, constructed and tested in the laboratory for its safe load carrying capacity and maximum deflection. A constant eccentricity of the tendon, e=115 mm is provided for all beams on the tension side using four numbers of high tensile 6 mm diameter wires [10].

Numerical analysis vs. experimental data

The results of the theoretical analysis show the maximum of 2.11% deviation of results between experimental data and numerical model that confirms the modeling of the system (Table 3).

Stage 1- Determining Optimal Stringer Shape

Case 1: Frame with I-beam as main stringer

The investigation for the I-section frame is done in three stages:

- Stage 1: Horizontal members are applied with straight prestressed loads over the full span of the frame
- Stage 2: Horizontal members are applied with straight prestressed loads over the full span of the frame with uniform eccentricity
- Stage 3: Horizontal members are applied with straight prestressed loads over the partial span of the frame with uniform eccentricity

Based on the results of these three stages, it is concluded that stage 3 is the most suitable condition to investigate further the flooring system for the criteria mentioned earlier.

The following data on a prestressed I-beam frame with a 10 m span serves as a sample for the kind of calculations made for each span length. All spans are subject to a maximum allowable stress of 275 N/mm² and an allowable deflection of the length divided by 200 (Table 4).

Case 2: Frame with truss as main stringer

To determine the most suitable type of truss to be used for the investigation of the flooring system in general, trial runs were done on flooring systems using three different types of trusses: Pratt, Warren with vertical chords, and Howe. After concluding the trials, it was determined that a Warren truss with vertical chords is more economical, and therefore will be used for the investigation of using a prestressed truss system as stringers. Particularly for this case, the prestressing load was only applied to the bottom chords, as the top chords are already in compression.

The data tabulated for a 10 m span frame below is only a sample of the calculations made for every span; the same conditions for max stress and deflection used in the previous case apply for the truss stringer frames (Table 5).

Stage 1: Results of optimization and analysis of the stringer shape

Based on the data collected from the I-beam and truss trials, Table 5 and 6 was produced comparing the percent reduction in the steel of the two different stringer types. This data is also presented as a graph for a more holistic view of the situation (Figure 6).

By observing the graph, one sees the optimum span for achieving maximum steel reduction in an I-beam frame is 30 m. The optimum span for achieving maximum steel reduction in the truss is 20 m. It is important to note, then, that each frames can be considered ideal only within a specific range that pivots somewhere between 20 m and 25 m.

Prestressed Steel Testing Frame Result From Experiment Straight tendon for entire span, e=115 mm						Prestressed Steel Testing Frame Results from STAAD Analysis straight tendon for entire span, e=115 mm						Prestressed Deviation from experimental data		
Prestressing Force (PF) KN	**Load carrying capacity (LL) KN**	**Max. Blending Moment KN-M**	**Ratio as per I.S.800 clause 7.1.1**	**Max. Deflection due to DL+PF (mm)**	**Max. Deflection due to DF+PF+LL (mm)**	**Prestressing Force (PF) KN**	**Load carrying capacity (LL)KN**	**Max. Blending Moment KN-M**	**Ratio as per I.S.800 clause 7.1.1**	**Max. Deflection due to DL+PF (mm)**	**Max. Deflection due to DF+PF+LL (mm)**	**Load carrying capacity (LL)KN**	**Max. Bending Moment KN-M**	**Max. Deflection due to DL+PF+LL (mm)**
0	412	91	0.999	0.014	3.46	0	408	89.4	0.999	0.014	3.38	0.971	1.758	2.23
25	436	93	0.998	0.040	3.67	25	432	91.7	0.998	0.039	3.59	0.971	1.371	2.12
50	449	93	0.999	0.070	3.77	50	444	91.4	0.997	0.069	3.70	1.114	1.720	1.97
75	448	90	0.999	0.100	3.76	75	443	88.5	0.998	0.098	3.69	1.220	1.692	1.99
100	447	87	0.999	0.130	3.76	100	442	85.5	0.999	0.127	3.68	1.230	1.758	2.14
125	446	84	0.99	0.160	3.75	125	440	82.5	0.998	0.157	3.67	1.240	1.905	2.21
150	445	81	0.999	0.190	3.74	150	440	79.5	0.999	0.186	3.66	1.200	1.852	2.11

Table 3: Results of Experimental data *vs.* Analytical Data from STAAD for testing frame.

Prestressed I-beam frame with straight tendon for partial span: Lp/L=0.5, e=-355 mm, L=10 m							
Prestressed Force (kN)	**Max Bending Moment at Midspan (kNm)**	**Max Bending Moment at End (kNm)**	**Utilization Ratio**	**Max Deflection due to DL and PF (mm)**	**Deflection due to DL, PF and LL (mm)**	**Max combined stress (N/mm²)**	**Steel Takeoff (kg)**
0	181	387	0.922	31.82	40.78	250.52	1043.5
100	165	368	0.827	28.6	37.63	238.6	
200	148	349	0.735	25.14	34.17	232.44	
300	132	330	0.717	21.68	30.71	266.28	
400	115	311	0.717	18.23	27.26	220.12	
500	99	292	0.806	14.77	23.8	213.96	
600	82	273	0.788	11.31	28.34	211.84	
700	66	254	0.93	7.85	16.88	247.14	
800	49	236	1.06	5.38	13.43	282.42	
Post-adjustment of member sizes for optimum sections							
600	85	270	0.919	14.17	17.43	244.12	987.6
Percent weight reduction 5.36							

Table 4: Overall results for a 10 m span I-beam frame.

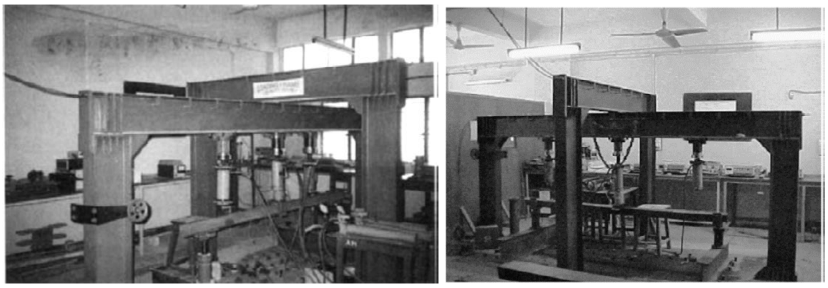

Figure 5: Testing Frame [10].

Prestressed truss frame with straight tendon for full span; L=10 m									
Prestressing Force (kN)	**Top Chord Axial Lord (kN)**	**Bottom Chord Axial Lord (kN)**	**Top Chord Ratio***	**Bottom Chord Ratio***	**Max Deflection due to DL and PF (mm)**	**Max Deflection due to DL, PF and LL (mm)**	**Top Chord Max Compressive Stress (N/mm^2)**	**Bottom Chord Max Tensile Stress (N.mm^2)**	**Steel Takeoff (kg)**
0	841	798	0.864	36.87	47.21	47.71	273.54	271.8	889.4
100	843	701	0.866	34	44.34	44.34	274.16	238.95	889.4
200	846	604	0.869	31.13	41.47	41.47	274.78	206.09	889.4
300	848	507	0.871	38.61	38.61	38.61	275.4	173.23	889.4
400	850	410	1.004	35.74	35.74	35.74	276.02	140.37	889.4
Post-adjustment of member size for optimum section									
300	844	-502	0.867	30.82	30.82	42.3	274.28	201.36	811.1
as per BS5950 Percent weight reduction 8.8									

Table 5: Overall results for a 10 m truss frame.

Span (m)	**Percent Reduction in Steel for**	
	Truss	**I-beam**
10	9.95	5.36
15	11.09	6.24
20	13.58	10.27
25	9.38	13.9
30	8.83	14.67
35		12.09

Table 6: Span versus percent reduction in steel.

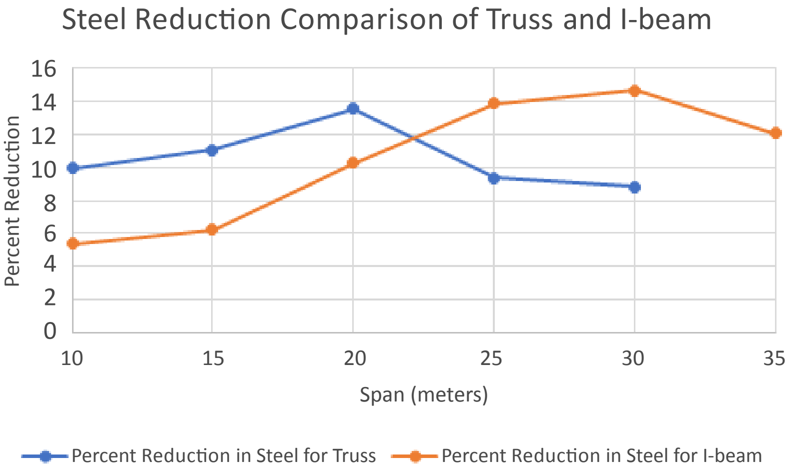

Figure 6: Comparing percent reduction in steel versus span.

A second factor to consider when comparing truss and I-beam frames is the steel takeoff, which is used to determine the amount of material needed for purchase and construction. It can be concluded that truss frames are more economical, as in all cases the takeoff is lower (Table 7).

Based on Table 7, it is evident that for long spans like 15-30 m even with prestressed loads; truss frames prove to be more economical than I section frames. With truss frames, steel consumption is 17%-25% less

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than the I section. Hence, truss frames are a more optimized alternative than I section frames.

Stage 2: Optimizing Tendon Profile for Truss Frame

As seen earlier, it was determined through the tests that a truss frame with a span of 20 m obtains maximum steel reduction. To further optimize this flooring system, it is useful to test out different tendon profiles for prestressing in truss frames: straight, curved and V-shaped (Figure 7).

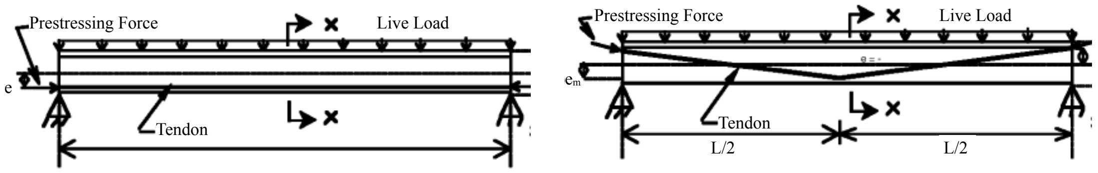
Analysis and results of the tendon profile optimization

The same numerical analysis performed in Stage 1 for the different frames (with data on axial loads, compressive stresses, and chord ratios) were performed on the 20 m truss, now with the three tendon profiles (Tables 8 and 9). Table 10 shows data on the percent reduction in weight for each profile.

The results indicate that using a straight tendon for the entire

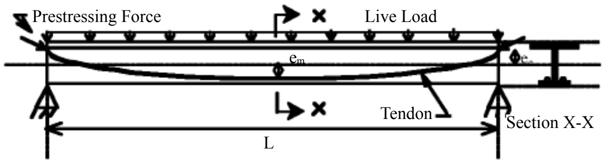
Span	Steel Take off in Kg				Lesser Steel Take off	% Lesser
	I-Beam		Truss			
	Non-prestressed	Prestressed	Non-Prestrssed	Prestressed		
10	1043.5	987.6	889.0	811.1	Truss	17.87
15	2104.8	1973.4	1689.9	1503.0	Truss	23.84
20	3856.3	3460.1	299.5	2589.0	Truss	25.18
25	6100.5	5252.3	4521.4	4041.0	Truss	23.06
30	9392.4	8014.8	6610.1	6026.2	Truss	24.81
35	13885.5	12206.7	-	-	-	-

Table 7: Comparison of steel takeoffs for truss and I-beam frames.



Straight tendon

V-shaped tendon profile



Curved tendon profile

Figure 7: Different type of assumed tendon profiles [11].

Prestressed Steel Truss Frame: Numerical Analysis: V-Shaped tendon inside, Span 20 m									
Prestressing Force (PF) KN	Axial Load Top Chord KN	Axial Load Bottom Chord KN	Ratio as per BS5950 Top Chord	Ratio as per BS5950 Bottom Chord	Max. Deflection due to DL+PF (mm)	Max. Deflection due to DL+PF+LL (mm)	Max. Combined Stress Top Chord N/mm²	Max. Combined Stress Bottom Chord N/mm²	Steel Takeoff Kg
0	1666	1655	0.927	0.967	93.09	93.09	254.80	266.01	2995.70
100	1669	1560	0.924	0.912	70.31	90.43	253.93	250.65	
200	1670	1462	0.921	0.856	67.49	87.61	253.17	235.30	
300	1672	1366	0.918	0.800	64.75	84.87	252.41	219.94	
400	1674	1270	0.919	0.759	62.01	82.13	252.65	204.58	
500	1676	1174	0.920	0.759	59.27	79.39	252.90	189.23	
600	1678	1078	0.921	0.759	56.55	76.65	253.15	173.87	
700	1680	981	0.921	0.759	53.83	73.92	253.40	158.52	
800	1682	885	0.923	0.759	51.12	71.21	253.79	143.16	
900	1684	789	0.931	0.759	48.40	68.49	256.13	127.80	
1000	1686	693	0.940	0.759	45.68	65.77	258.48	112.45	
1100	1688	597	0.948	0.759	42.97	63.06	260.83	97.09	
1200	1690	500	0.957	0.759	40.25	60.34	263.17	99.23	
1300	1692	404	0.966	0.759	37.54	57.63	265.52	114.65	
1400	1694	308	0.974	0.790	34.82	54.91	267.87	130.06	
After changing the member sizes to get optimum sections with a prestressed load of 1300 KN									
1300	1697	412	0.911	0.965	38.09	61.04	274.53	263.50	2685.00
% Total reduction in steel weight=10.37									

Table 8: Analysis results of the V-shaped tendon profile.

Prestressed Steel Truss Frame: Numerical Analysis: Curved tendon inside, Span 20 m									
Prestressing Force (PF) KN	**Axial Load Top Chord KN**	**Axial Load Bottom Chord KN**	**Ratio as per BS5950 Top Chord**	**Ratio as per BS5950 Bottom Chord**	**Max. Deflection due to DL+PF (mm)**	**Max. Deflection due to DL+PF+LL (mm)**	**Max. Combined Stress Top Chord N/mm²**	**Max. Combined Stress Bottom Chord N/mm²**	**Steel Takeoff Kg**
0	1666	1655	0.927	0.967	93.09	93.09	254.80	266.01	2995.70
100	1669	1560	0.924	0.912	70.31	90.43	253.93	250.65	
200	1670	1462	0.921	0.856	67.49	87.61	253.17	235.30	
300	1672	1366	0.918	0.800	64.75	84.87	252.41	219.94	
400	1674	1270	0.919	0.759	62.01	82.13	252.65	204.58	
500	1676	1174	0.920	0.759	59.27	79.39	252.90	189.23	
600	1678	1078	0.921	0.759	56.55	76.65	253.15	173.87	
700	1680	981	0.921	0.759	53.83	73.92	253.40	158.52	
800	1682	885	0.923	0.759	51.12	71.21	253.79	143.16	
After changing the member sizes to get optimum sections with a prestressed load of 500 KN									
500	1678	1174	0.939	0.989	59.27	70.20	274.53	258.25	2758.00
% Total reduction in steel weight=7.93									

Table 9: Analysis results of the curved tendon profile.

Tendon Style	**Percent weight Reduction**
Straight for entire span	13.58
V-Shape inside	10.37
Curved inside	7.93

Table 10: Percent reductions in weight for a 20 m span truss with different tendon profiles.

Frame type	**Weight of frame (metric Ton)**	**Prestressing weight (metric ton)**	**Total weight (metric ton)**	**Price (£/ton)**	**Total Price (£/ton)**
Non-prestressed	2.995	0	2.995	2000	5990
Prestressed	2.589	0.195	2.784	2000	5568

Table 11: Cost comparison of different truss frames with 20 m spans.

span, along with prestressing the bottom chord of the truss, is the most economical option.

Stage 3: Cost-Benefit Analysis

The cost-benefit of this flooring system is calculated in part based on data available from the British Constructional Steelwork Association (BCSA) website [17], with the base of installation cost for prestressed steel is £2000 for a metric ton. Also, it is matched to the costs of the steel structure in the US. Prestressing data are also pulled from PAUL Maschinenfabrik GmbH & Co. KG, a leading company in prestressing technology (max prestressing force of 1500 KN, the weight due this force is 195 kg.) After combining these two facts with measurements specific to a 20 m span truss frame (as the best fit for prestressing), from this cost analysis, one can see that a prestressed truss flooring allows for a 7.6 percent decrease in price due to lower material takeoff. Granted, prestressing itself has associated costs, but future developments in the process will improve the economic benefit even further. (Table 11). It can be concluded that the prestressed flooring system has enough potential to be economically and commercially viable.

Conclusion

The numerical analysis of the truss bent, and steel frame with I sections was investigated with the goal of finding an optimal configuration of prestressing tendons, optimal span, optimal system, and to understand the most economic system. The results show that a prestressed flooring system could be economically viable for constructing buildings. This system can be adopted for any kind of building which requires an average span in the range 15-25. This system is also recommended for extension in the existing buildings as being lightweight, lesser construction time and reduced material weight as compared to its non-prestressed equivalent. The following observations can be drawn from the analyses of all three stages:

- For I-beams as the main stringer, a 30 m span is optimal, with maximum reduction in the steel of 18.78 percent.
- Using a truss as the main stringer, a 20 m span is optimal, span with maximum reduction in the steel of 13.58 percent.
- When I-sections are compared with truss for the same spans, in each case truss proved to be more economical than I sections as the steel takeoff was less by 17% to 25% for span 10 to 30 m.
- When results of different tendon profile with truss are compared, straight tendon proved to be most economical with percentage reduction is steel as 13.58% as compared to 10.27% for V-shaped tendons and 7.93% for curved tendons.
- On observing all the graphs, it can be deduced that along with a reduction in weight, prestressing also contributes to reduction in the deflection of the stringer as compared to the non-prestressed frame.
- The numerical results from the software give nearly the same result as the experimental data with a maximum deviation of 2.23%.
- Based on the analysis results, a flooring system is proposed for a span 15-25 m with prestressed truss as main stringer, prestressed over the entire span with straight tendons. This system will have 10%-13% of steel reduction when compared to the non-prestressed system.
- A flooring system with prestressed steel is an economically

viable option, with a 7.6 percent decrease in cost compared to the same non-prestressed system.

- It can be concluded that the prestressed flooring system for a span of 10 to 35 m with straight tendons over the entire span has enough potential to be economically and commercially viable.

Acknowledgments

Some part of this research was conducted at Heriot Watt University through a graduate MSc dissertation. The first and second author would like to thank the school of the built environment at Heriot Watt University (Dubai Campus) for their support.

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