Analysis of a Cable-stayed Bridge On STAAD PRO

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Keywords:
cable-stayed bridge;
erection stress;
modal analysis;
bridge

A B S T R A C T

In the construction of long span beam, the bridge is in linear with the requirement of the design alignment is the key to ensure that the bridge is in a reasonable stress state, the safety of the bridge operation and the beautiful appearance of the bridge. There are several parameters used Beam Size = 0.5 x 0.45 m, Column size = 0.5 x 0.5 m, Column cross-section: Rectangular and Tower H shape. There are several applications that require accurate models such as: earthquake or wind simulations, health monitoring and structural control.

1. Introduction

Studies of the dynamic effects on bridges subjected to moving masses are carried out ever since the primary railway bridges were in-built the first 19th century. Since that point vehicle speed and vehicle mass to the bridge mass ratio are enhanced, leading to much larger dynamic effects. In current years, the concern in traffic induced vibrations has been increasing because of overview of high speed vehicles, just like the TGV train in France and also the Shinkansen train in Japan with speeds exceeding 300 km/h. The increasing dynamic effects aren't only imposing severe conditions upon bridge style however additionally upon vehicle style, so as to provide a suitable level of comfort for the passengers. Cable stayed bridges date back several centuries; the system was employed by Egyptians for their sailing ships. Quick Chinese folks used the cable-stayed system to construct suspension bridges out of hemp rope and iron chains.

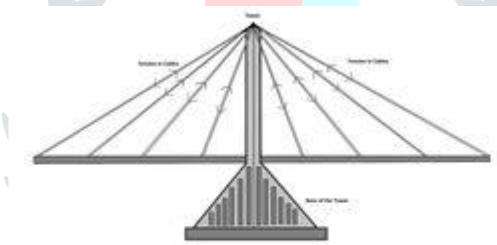


Fig.1 Cable Stayed Bridge

Cable types

Different types of cables are used in cable-stayed bridges; their form and configuration depend on the way individual wires are assembled. The steel used for the cables is stronger than ordinary steel. A strand is commonly composed of 7 wires, helically molded around a center wire; the wire diameter is between 3 and 7 mm. The strands are carefully packed together and usually bounded with a helical strand.

Cables are the most vital parts in cable-stayed bridges; they carry the load from the structure to the tower and to the backstay cable anchorages. Additionally to high tensile strength, they need to even have high fatigue resistance and corrosion protection.

1. Helically-wound galvanized strands.
   Ultimate Tensile Stress σu =670 MPa
   Young Modulus E = 165 000 MPa
2. Parallel wire strands. Ultimate Tensile Stress σu =1860 MPa
   Young Modulus E = 190 000 MPa
3. Strands of parallel wire cables.
   Ultimate Tensile Stress σu =1 600 Mpa
   Young Modulus E = 200 000 MPa
4. Locked coil strands.
   Ultimate Tensile Stress σu =1500 MPa
   Young Modulus E = 170 000 MPa

The Allowable Stress under dead load effect for the cables under dead load is:

Each cable kind has benefits and drawbacks. As an example, secured coil strands have variable stress-strain behaviour and low fatigue strength at the sockets. Therefore, they're less of times used. It's higher to decide on a kind of cable wherever the modulus of elasticity is high and constant. The parallel wire strand is the most commonly cable type.

2. METHOD

Selection of Study Area: Cable-stayed Bridge was considered for the area of research and study.

The Cable-stayed Bridge modelling and analysis is done in STAAD PRO software.

Staad-Pro

STAAD.PRO is the Structural analysis and Design Software established by Bentley System Inc. founded by Mr. Keith A. Bentley in conjunction with his brother Mr. Barry J.Bentley in 1984. The present version of STAAD-pro is STAAD-pro V8i is one of the most awaited structural analysis and design software. It has the provision for steel works, concrete design codes. It is used to analyses various structural forms from the traditional static analysis, p-delta analysis and geometrical non-linear analysis.

Modelling of Bridge

Steps for modelling cable stayed bridge in Staad Pro are as follows:-

- Defining Material
- Sectional properties
- Tower modelling
- Boundary condition input- End support at both ends are simply supported whereas base of pylon is fixed
- Loading condition input based on type of analysis
- Finding initial pretension force in cables
- Defining Construction stages

Load considered

- Dead load
- Live load
- Seismic load (zone 4)

Considered input parameters in the present study

- Beam Size = 0.5 x 0.45 m
- Column size = 0.5 x 0.5 m
- Column cross-section: Rectangular
- Tower H shape

Erection stress

Erection stresses are encouraged by the equipment used while construction of the bridge. These can be repelled by providing appropriate supports regarding the members under load. In the present study the erection stresses are calculated analytically and result graphs are plotted.

Relaxation

Relaxation is defined because the loss of stress during a stressed material control at constant length. Another manifestation of identical basic phenomenon, creep, is outlined because the modification long of a material under stress. Since no usually satisfactory quantitative relationship between creep and relaxation has been developed, relaxation tests ought to be allotted whenever relaxation data are required, though creep tests are easier to perform.

Relaxation characteristics of pre-stressing reinforcement are of interest in pre-stressed concrete construction, though pure relaxation does not exist underneath sensible conditions. Creep and shrinkage of the concrete and fluctuations in superimposed load modification the length of the tendon. All the same, the tendon doesn't deform freely and therefore the stress in it wills modification. Thus, the conditions are comparable a lot of to a relaxation test than to a creep test.

The attitude toward the impact of relaxation has modified significantly over the last 20 years. At first, relaxation losses were thought-about to be quite essential as a result of the affected the operating stresses that governed the design.

At identical time, it had been thought that the reinforcement reached a stable stress during a matter of many weeks if not hours which the relaxation losses were restricted to a very little fraction of the initial stress.

The maximum tensile stress throughout prestressing (fpi) shall not exceed 80t%of the characteristic strength.

$fpi \leqslant 0.8fpk$

The stress versus strain behaviour of prestressing steel under uniaxial tension is at the start linear (stress is proportional to strain) and elastic (strain is recovered at unloading).

Beyond regarding 70th of the last word strength the behaviour becomes nonlinear and inelastic. There's no defined yield purpose.

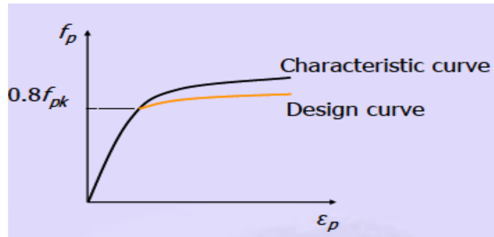


Fig.2 Characteristic and design stress-strain curves

3. RESULT AND DISCUSSION

Complete modelling and analysis of Cable-stayed Bridge is done in STAAD PRO software.

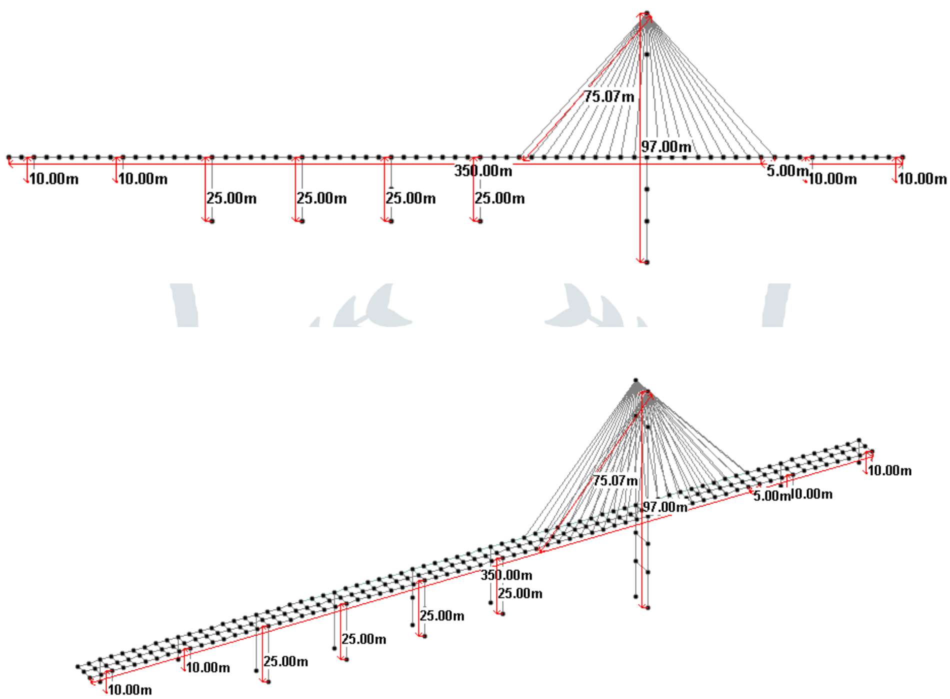


Fig.3 Design of Proposed Bridge

Beam Size = 0.5 x 0.45 m

Column size = 0.5 x 0.5 m

Column cross-section: Rectangular

Tower H shape

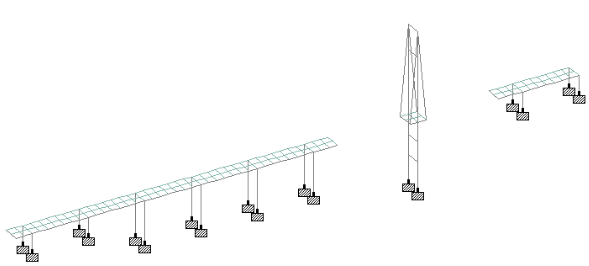


Fig.4 5 m span

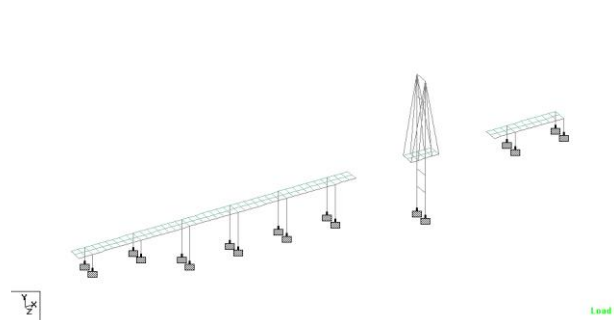


Fig.5 10 m span

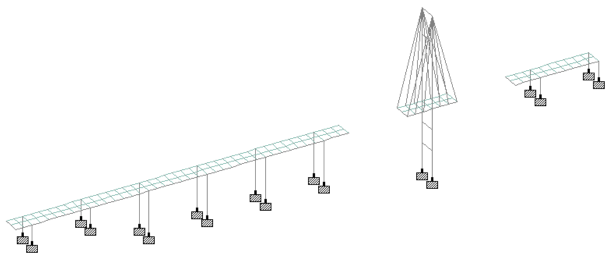


Fig.6 15 m span

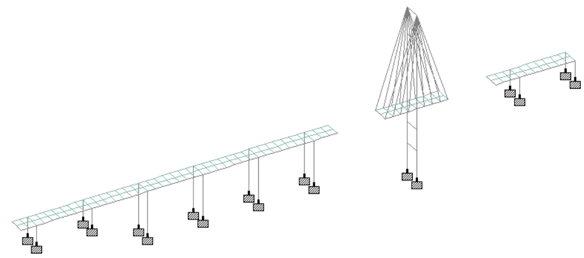


Fig.7 20 m span

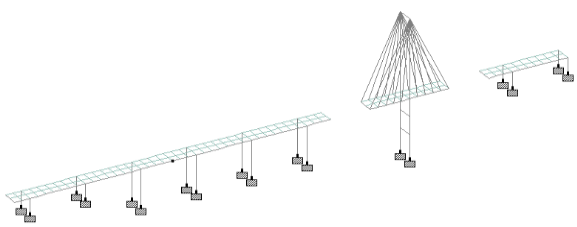


Fig.8 25 m span

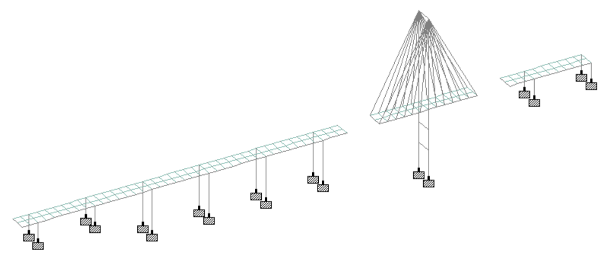


Fig.9 30 m span

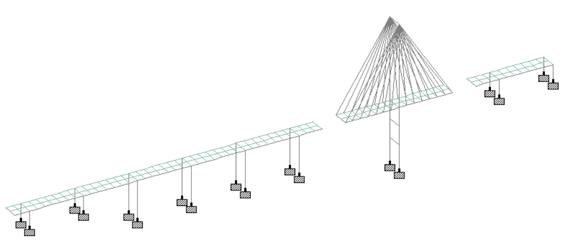


Fig.10 35 m span

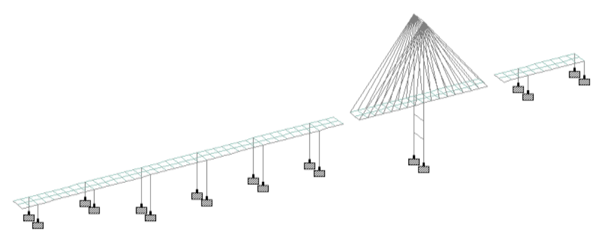


Fig.11 40 m span

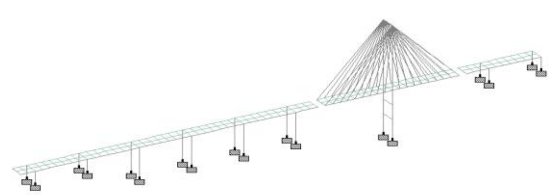
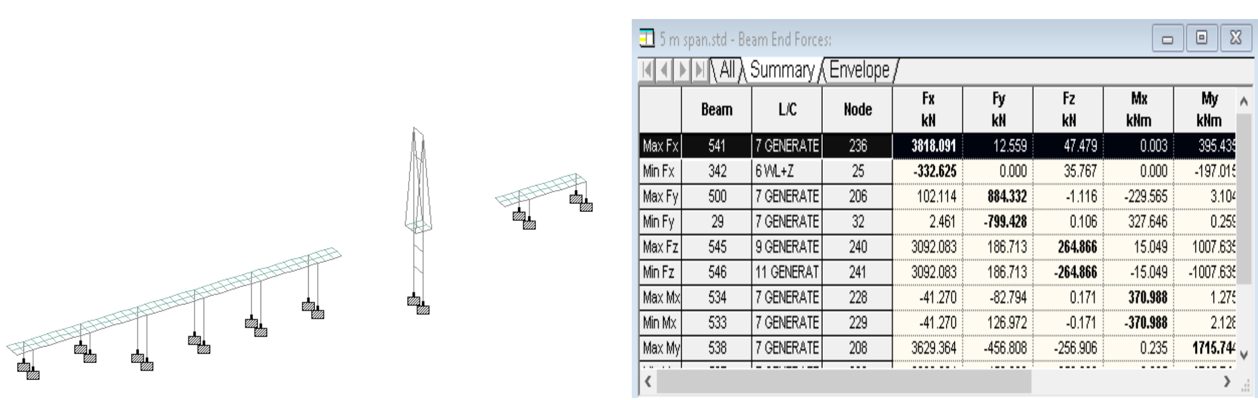


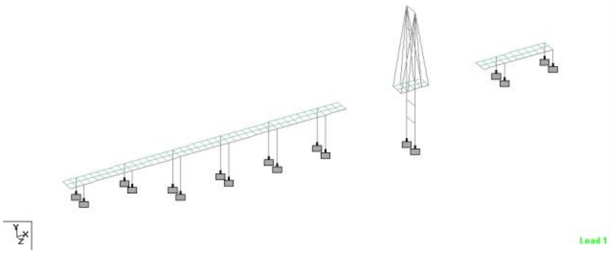
Fig.12 45 m span

Cable forces



	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	541	7 GENERATE	236	3818.091	12.559	47.479	0.003	395.43
Min Fx	342	6 WL+Z	25	-332.625	0.000	35.767	0.000	-197.01
Max Fy	500	7 GENERATE	206	102.114	884.332	-1.116	-229.565	3.10
Min Fy	29	7 GENERATE	32	2.461	-799.428	0.106	327.646	0.25
Max Fz	545	9 GENERATE	240	3092.083	186.713	264.866	15.049	1007.63
Min Fz	546	11 GENERAT	241	3092.083	186.713	-264.866	-15.049	-1007.63
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	370.988	1.27
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	-370.988	2.12
Max My	538	7 GENERATE	208	3629.364	-456.808	-256.906	0.235	1715.74

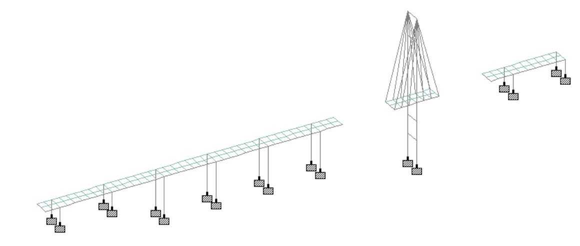
Fig.13 Cable forces applied on 5 m span



5 m span.std - Beam End Forces:

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	541	7 GENERATE	236	**3818.091**	12.559	47.479	0.003	395.43
Min Fx	342	6 WL+Z	25	**-332.625**	0.000	35.767	0.000	-197.01
Max Fy	500	7 GENERATE	206	102.114	**884.332**	-1.116	-229.565	3.10
Min Fy	29	7 GENERATE	32	2.461	**-799.428**	0.106	327.646	0.25
Max Fz	545	9 GENERATE	240	3092.083	186.713	**264.866**	15.049	1007.63
Min Fz	546	11 GENERAT	241	3092.083	186.713	**-264.866**	-15.049	-1007.63
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	**370.988**	1.27
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	**-370.988**	2.12
Max My	538	7 GENERATE	208	3629.364	-456.808	-256.906	0.235	**1715.74**

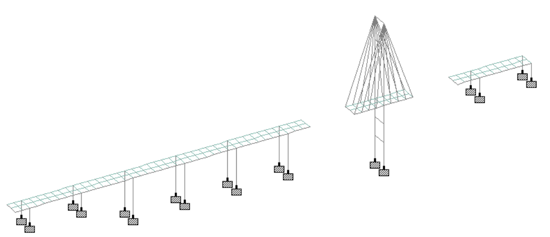
Fig.14 Cable forces applied on 10 m span



15 m span.std - Beam End Forces:

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	341	7 GENERATE	138	**4196.800**	-0.000	3.287	-0.000	17.49
Min Fx	342	6 WL+Z	25	**-482.140**	0.000	53.005	0.000	-285.44
Max Fy	500	7 GENERATE	206	102.114	**884.332**	-1.116	-229.565	3.10
Min Fy	29	7 GENERATE	32	2.461	**-799.428**	0.106	327.646	0.25
Max Fz	545	9 GENERATE	240	3092.083	186.713	**264.866**	15.049	1007.63
Min Fz	546	11 GENERAT	241	3092.083	186.713	**-264.866**	-15.049	-1007.63
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	**370.988**	1.27
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	**-370.988**	2.12
Max My	538	7 GENERATE	208	3629.364	-456.808	-256.906	0.235	**1715.74**

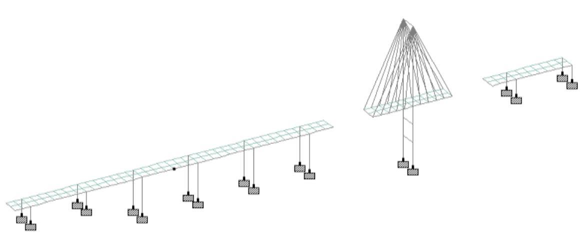
Fig.15 Cable forces applied on 15 m span



20 m span.std - Beam End Forces:

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	341	7 GENERATE	138	**5248.127**	-0.000	3.381	-0.000	17.99
Min Fx	342	6 WL+Z	25	**-558.560**	0.000	61.766	0.000	-330.38
Max Fy	500	7 GENERATE	206	102.114	**884.332**	-1.116	-229.565	3.10
Min Fy	29	7 GENERATE	32	2.461	**-799.428**	0.106	327.646	0.25
Max Fz	545	9 GENERATE	240	3092.083	186.713	**264.866**	15.049	1007.63
Min Fz	546	11 GENERAT	241	3092.083	186.713	**-264.866**	-15.049	-1007.63
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	**370.988**	1.27
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	**-370.988**	2.12
Max My	538	7 GENERATE	208	3629.364	-456.808	-256.906	0.235	**1715.74**

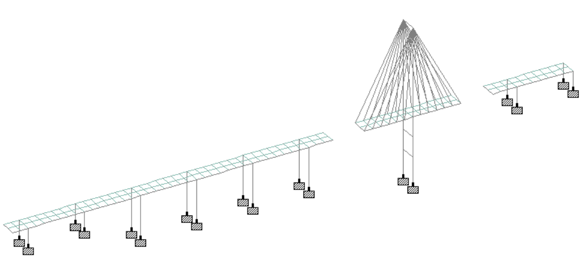
Fig.16 Cable forces applied on 20 m span



25 m span.std - Beam End Forces:

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	341	7 GENERATE	138	**6300.293**	-0.000	3.436	-0.000	18.28
Min Fx	342	6 WL+Z	25	**-636.504**	-0.000	70.658	-0.000	-375.98
Max Fy	500	7 GENERATE	206	102.114	**884.332**	-1.116	-229.565	3.10
Min Fy	29	7 GENERATE	32	2.461	**-799.428**	0.106	327.646	0.25
Max Fz	545	9 GENERATE	240	3092.083	186.713	**264.866**	15.049	1007.63
Min Fz	546	11 GENERAT	241	3092.083	186.713	**-264.866**	-15.049	-1007.63
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	**370.988**	1.27
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	**-370.988**	2.12
Max My	538	7 GENERATE	208	3629.364	-456.808	-256.906	0.235	**1715.74**

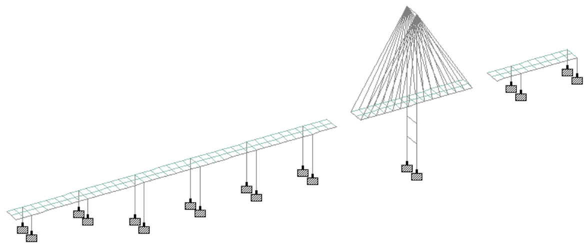
Fig.17 Cable forces applied on 25 m span

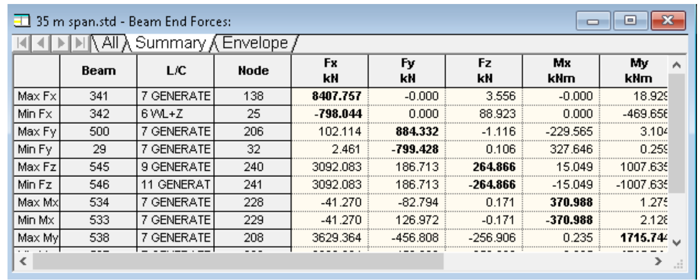


30 m span.std - Beam End Forces:

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	341	7 GENERATE	138	**7353.456**	-0.000	3.493	0.000	18.59
Min Fx	342	6 WL+Z	25	**-716.248**	0.000	79.703	0.000	-422.37
Max Fy	500	7 GENERATE	206	102.114	**884.332**	-1.116	-229.565	3.10
Min Fy	29	7 GENERATE	32	2.461	**-799.428**	0.106	327.646	0.25
Max Fz	545	9 GENERATE	240	3092.083	186.713	**264.866**	15.049	1007.63
Min Fz	546	11 GENERAT	241	3092.083	186.713	**-264.866**	-15.049	-1007.63
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	**370.988**	1.27
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	**-370.988**	2.12
Max My	538	7 GENERATE	208	3629.364	-456.808	-256.906	0.235	**1715.74**

Fig.18 Cable forces applied on 30 m span



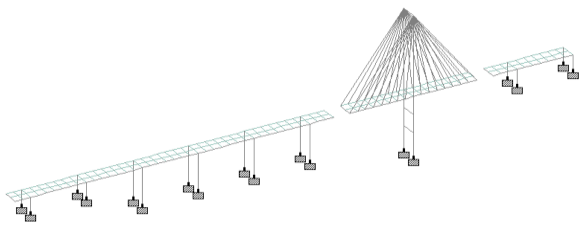


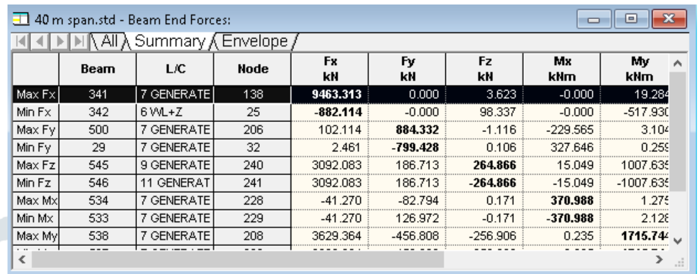
35 m span.std - Beam End Forces:

All | Summary | Envelope

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	341	7 GENERATE	138	**8407.757**	-0.000	3.556	-0.000	18.929
Min Fx	342	6 WL+Z	25	**-798.044**	0.000	88.923	0.000	-469.656
Max Fy	500	7 GENERATE	206	102.114	**884.332**	-1.116	-229.565	3.104
Min Fy	29	7 GENERATE	32	2.461	**-799.428**	0.106	327.646	0.259
Max Fz	545	9 GENERATE	240	3092.083	186.713	**264.866**	15.049	1007.635
Min Fz	546	11 GENERAT	241	3092.083	186.713	**-264.866**	-15.049	-1007.635
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	**370.988**	1.275
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	**-370.988**	2.128
Max My	538	7 GENERATE	208	3629.364	-456.808	-256.906	0.235	**1715.744**

Fig.19 Cable forces applied on 35 m span



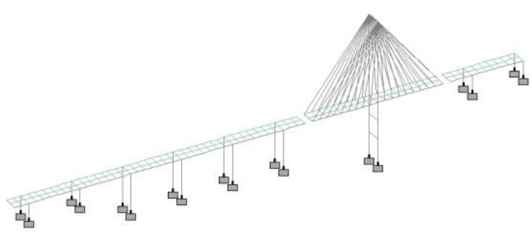


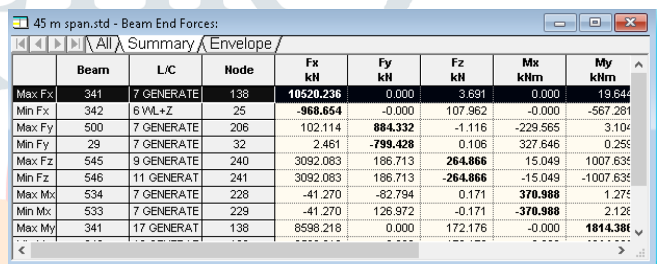
40 m span.std - Beam End Forces:

All | Summary | Envelope

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	341	7 GENERATE	138	**9463.313**	0.000	3.623	-0.000	19.284
Min Fx	342	6 WL+Z	25	**-882.114**	-0.000	98.337	-0.000	-517.930
Max Fy	500	7 GENERATE	206	102.114	**884.332**	-1.116	-229.565	3.104
Min Fy	29	7 GENERATE	32	2.461	**-799.428**	0.106	327.646	0.259
Max Fz	545	9 GENERATE	240	3092.083	186.713	**264.866**	15.049	1007.635
Min Fz	546	11 GENERAT	241	3092.083	186.713	**-264.866**	-15.049	-1007.635
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	**370.988**	1.275
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	**-370.988**	2.128
Max My	538	7 GENERATE	208	3629.364	-456.808	-256.906	0.235	**1715.744**

Fig.20 Cable forces applied on 40 m span





45 m span.std - Beam End Forces:

All | Summary | Envelope

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	341	7 GENERATE	138	**10520.236**	0.000	3.691	0.000	19.644
Min Fx	342	6 WL+Z	25	**-968.654**	-0.000	107.962	-0.000	-567.281
Max Fy	500	7 GENERATE	206	102.114	**884.332**	-1.116	-229.565	3.104
Min Fy	29	7 GENERATE	32	2.461	**-799.428**	0.106	327.646	0.259
Max Fz	545	9 GENERATE	240	3092.083	186.713	**264.866**	15.049	1007.635
Min Fz	546	11 GENERAT	241	3092.083	186.713	**-264.866**	-15.049	-1007.635
Max Mx	534	7 GENERATE	228	-41.270	-82.794	0.171	**370.988**	1.275
Min Mx	533	7 GENERATE	229	-41.270	126.972	-0.171	**-370.988**	2.128
Max My	341	17 GENERAT	138	8598.218	0.000	172.176	-0.000	**1814.386**

Fig.21 Cable forces applied on 45 m span

Table 1 Cable forces on different span

Cable forces (KN)	Span (m)
3818.091	5
3818.091	10
4196.00	15
5248.12	20
6300.29	25
7353.45	30
8407.75	35
9463.31	40
10520.23	45

Table 2 Erection Stress

Erection stress (N/mm^2) (Min)	Erection stress (N/mm^2) (Max)	Span (m)
3.0012	36.7805	5
2.2762	34.624	10
2.3411	34.628	15
2.4076	34.632	20
2.4069	34.632	25
2.3748	36.780	30
2.3387	34.627	35
2.30629	34.625	40
2.27699	34.624	45

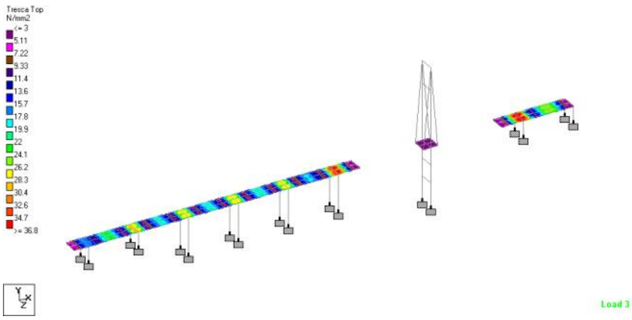


Fig.22 Erection stress on 5 m span

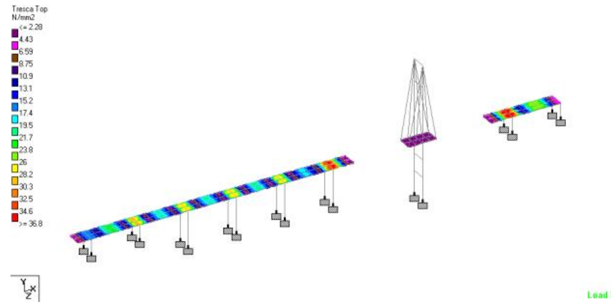


Fig.23 Erection stress on 10 m span

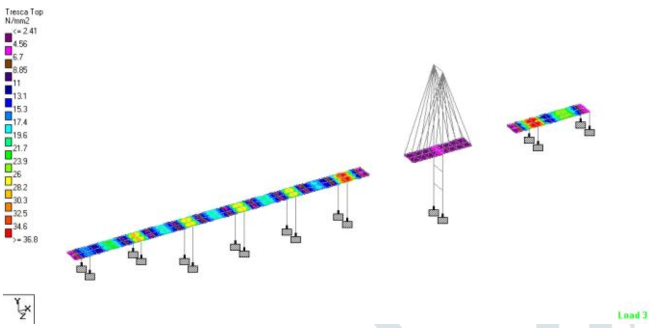


Fig.24 Erection stress on 20 m span

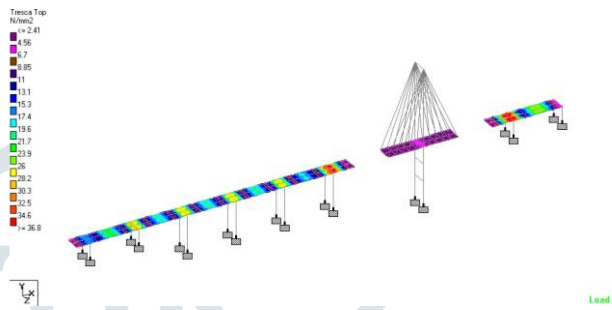


Fig.25 Erection stress on 25 m span

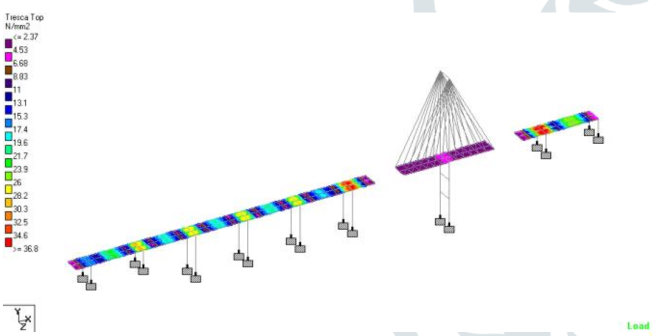


Fig.26 Erection stress on 30 m span

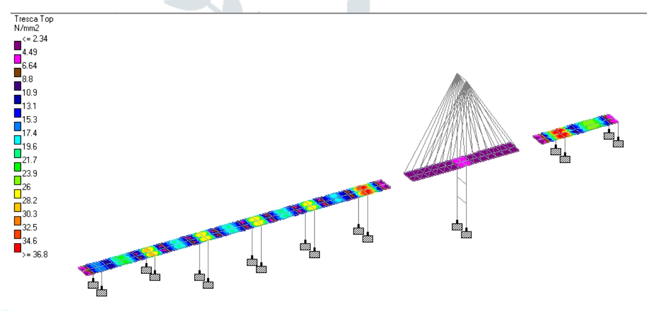


Fig.27 Erection stress on 35 m span

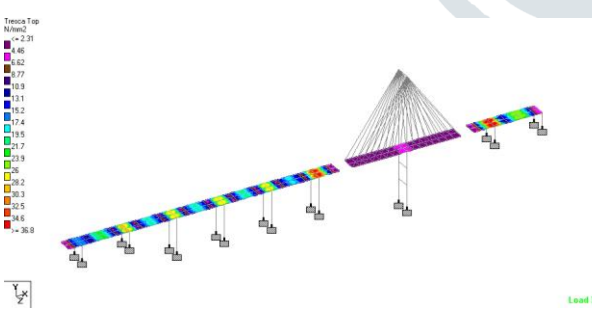


Fig.28 Erection stress on 40 m span

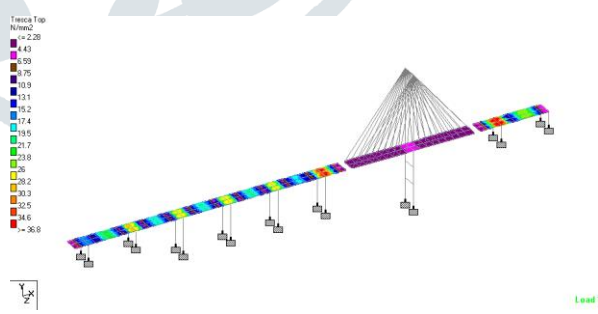


Fig.29 Erection stress on 45 m span

4. CONCLUSION

In this paper modelling design and Analysis of a Cable-stayed Bridge on STAAD.PRO software. The cable-stayed bridge is a bridge type which is common application today with larger applicable scope of span, and good-looking appearance. After half a century, the technology of cable-stayed bridge got unprecedented development. In the analysis of Cable Bridge on STAAD PRO software cable forces of 5m span is -332.625KN is minimum and 3818.091KN is maximum. After that erection stress of 5m span is 3.0012N/mm² is minimum and 36.7805N/mm².

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