Analysis Of Cable Supported Bridge(S) - A Review

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Abstract –

The infrastructural development along the Globe has given rise to an urge for bridges, bridging over super long spans. Bridges supported on Cable systems which can be fingured out as Cable supported bridges , in general subcategorized in as Cable Stayed &/or Suspension type of cable system; generally constitute for Long to super long span bridges. To have an edge, for a better cost/utility ratio, in the present scenario, the importance and hence the need for different materials, construction methodologies adopted govern the basic pointer. Primarily and predominantly, CSB's and SB's have been preferred for bridges garnering very long or say super long spans (herein ,spans are generally in multiples of 100m). It is very much clear and understood that that CSB's and SB's have their own need, merits & certain demerits too. So as an innovative thought and approach thereby, preference to CSSHB may incorporating merits of both CSB and SB respectively

Keywords- Cable Stayed Bridges; Suspension Bridge; cable sag to main span ratio; dynamic analysis, Cable Stayed Suspension Hybrid Bridge.

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I-INTRODUCTION

It has been witnessed that,in the human settlement , one of the most important role is played/observed by the act of Bridging.T hereby the need of Bridges came into picture. The determination of the best possible kind of bridge is resolved dependent on the result/output of surveys conducted for topographic review, geographical overview, traffic study, geotechnical study, hydro specialized review, seismic study, and meteorological overview, and so forth ., just as the cost, ecological effect, and style. The span of the bridge is one of the most important parameter which governs the design criteria for any bridge. In addition to this , thereforth, the material , namely concrete, steel etc., to be adopted for construction of bridge and its superstructure also plays an important role for deciding the the system of superstructure . When the bridges are to be designed for spans of medium range,truss bridges ,contiuous girder type bridges may be considered as an alternative. However, for spans greater than 500m, Bridge superstructures which use Cable supported system offer a promising solution. This system may be either as Cable Stayed Bridges, Suspension Bridges or their combination thereon. A CSB is considered as preferred replacement to the SB for spans up to 600 m. Even though , and the largest span of CSB is 1104 m, yet , for bridges for span length greater than 1000 m, a SB is still considered as a better alternative

1.1 Necessity of long to Superlong Span Bridges

The longer bridge spans provide and facilitate increased horizontal clearance available for navigation thereby substantial reduction in possible collision(s) of navigating ship(s) collisions with each other &/or piers. Moreover, in today's world of trade war and economic competition, the longer span imparts various economic impacts, enumerated as

(a). The collapse of superstructure may result in closing or impairment of port and/or traffic.
(b). The Bridge subjected to repair or replacement or M&R.
(c). This brings and adds to our necessity, a pre-thought that span of greater length should be

considered to cater with the requirements of channels / pathways/ waterways for navigation/transportation

A cable Supported bridge may adopt systems viz.

1. Cable Stayed Bridge (**CSB**, abbreviated now onwards)
2. Suspension type Bridges (**SB**, abbreviated now onwards)
3. Modified system which incorporates both of above systems i.e Cable-Stayed-Suspension-Hybrid-Bridge **(CSSHB,** abbreviated now onwards)

The Table 1 below enlists brief details of some of the leading cable supported bridges of the 20^{th}-21^{st} century garnering long spans (>800m)

Table. 1. Brief : Leading Cable Supported Bridges(1)

Sr	Bridge Name	Type	Country	Center Span (>800 m)	Year of Completion
1	Russky_	CSB (Steel Bridge)	Russia	1104	2012
2	Stonecutter		Hong Kong	1018	Mid 2008
3	Tatara		Japan	890	1999
4	Normandie		France	856	1994
5	Sutong	CSB (Composite Bridge)	China	1088	2008
6	Incheon		S.Korea	800	2009
7	Hutong Yangtze	CSB (Recent)	China	1092	2019
8	Qingshan Yangtze		China	938	2019
9	Jiayu Yangtze		China	920	2019
10	Chizhou Yangtze		China	828	2018
11	Akashi-Kaikyo	SB	Japan	1991	1998
12	Xihoumen		China	1650	2009
13	Great Belt East		Denmark	16245	1998
14	Gwangyang		Korea	1545	2012
15	Runyang South		China	1490	2005
16	Humber		U.K.	1410	1981
17	Tsing Ma		HongKong	1377	1997
18	Golden Gate		USA	1280	1937
19	Meckinak Strait		USA	1158	1957
20	Minami Bisan-Seto		Japan	1100	1988
21	Fateh Sukta Mehmet		Turkey	1090	1988
22	Forth Road		U.K	1005	1964
23	Shimotsui Seto		Japan	940	1988
24	Hu Men Zhu Jiang		China	888	1997
25	Askey		Norway	850	1992

II-. CABLE STAYED BRIDGE (CSB)

When a structural system comprising of a deck, which is continuous, is connected using cable stays(inclined) to the tower(Pylon) as shown in Figure 1 below; then the bridge so formed is termed as a Cable-Stayed type of Cable supported Bridge. The concept is simple that all the members work under Compression or Tension with inclined cable stays working as elastic supports to carry vertical loads (there is meager influence of flexure and shearin deck). The CSB holds first preference over cantilever bridge, truss bridge, arch bridges etc for spans from 150m-600m owing to its elegancy & economy on account of smaller girder depth needed.

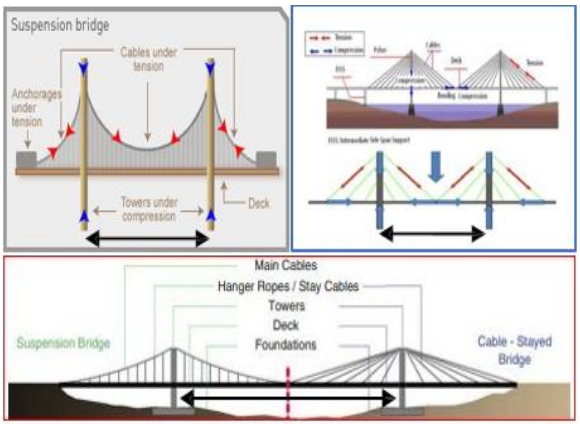

Fig.. 1.: Schematic Geometric Configuration & Forces in Bridge(SB & CSB) Components

A Cable Stayed Bridge can be classified based on

1. Span: single, two ,three , 4(or multi) span
2. Stay Cable Arrangement: Mono, Fan, Modified Fan , Harp
3. Lateral Cable Arrangement: Single, Two, Three plane

The merits of adopting CSB can be summarized as

- Aesthetically Pleasing
- Are Strong
- Have High Degree of Redundancy
- Take less Time to build
- Are Most Economical
- Efficient Use of materials
- Uncomplicated &
- lighter superstructure
- Comparatively smaller vertical deflections
- Low Span-Depth ratio feasible

However, it does possess certain disadvantages such as

- They may not prove to be stable
- More suitable for Over-crossing shorter spans(Not ideally recommended for spans which are too large/long)
- Inspection & Maintenance may be difficult especially Soft Ground Issues

For analysis of cable-stayed bridge an iterative approach adopted. This includes determination

of the post-tensioning cable forces due to effect of selfweight i.e. in the DL configuration (initially) from flexibility matrix of the structure. The analysis namely static and dynamic can be summaried as:

Kao and Kou (2010)(2) submitted analysis of a symmetrical, cable-stayed bridge, with fan-type cable configuration under sudden breakage of cable (keeping in consideration it as the most critical phenomenon in the analysis). They determined the dynamic response of the entire bridge

Wolff and Starossek(2008)(3) submitted a study of a 3d csb model towards collapse behaviour & revealed that the initial failure (loss) of the three cables around the pylon can lead to triggering of a zipper-type collapse . Subseuently, snapping of cables adjacent to the cables lost is observed owing to high stress concentration. It was also noticed that location of the lost cable is very important .Zhang & Wu(2011) (4) analyzed cable stayed bridge with dead stage analysis using Midas. Rageh and Maslennikov(2013)(5) examined the influence of the arrangements of cable on the bridge deformation considering nonlinear static and modal analysis using SAP2000 with different cable arrangement system.

Table 2 : Research Papers :: Static Analysis Procedures for CSB's (In Brief)(6)

Sr. No.	Researchers	Year	Contents
1.	Bryan. Smith	1967	Co- efficient method for modifying rigidity.
2.	Stafford S.	1968	Linear compatibility equation for bridges.
3.	Man Tang. C.	1971	Influence line for cable bridge.
4.	Lazer B. E.	1972	Elastic support concept for deck.
5.	Wilson E. L	1974	Gauss elimination method using software.
6.	Farm A.	1975	Finite elements for curved box girder.
7.	Das R. S.	1976	Deflection theory using successive iteration.
8.	Peyrot A. H.	1979	3-D study considering cable sag.
9.	Yew C. L.	1983	Simplified finite strip analysis.
10.	Haegab H.L.A.	1985	Potential energy and Fourier method.
11.	Como M.	1985	Truss analogy method for bridge.
12.	Gopal Samy P.	1988	Deck as a elastic line in Maclaurin series.
13.	Raman N.V.	1988	Large displacement analysis.
14.	Fakhrey Ella A	1989	Soil-structure interaction effect on analysis.
15.	James M.S.	1991	Monte Carlo simulation for fatigue.
16.	Jankins W.M.	1992	Genetic Algorithm for optimum design.
17.	Galuta E.M.	1995	Finite element method for composite box girder.
18.	Yoram R.	1995	Artificial Intelligence techniques for bridges.
19.	Hyo Nam Cho	1996	Reliability analysis for safety assessment.
20.	Negrao J.H.D.	1997	Optimization of 3-D bridges.
21.	Curran P.	1999	Experimental static analysis.
22.	Cobo del Arco	2001	Artificial Neural network for bridges.
23.	Robert J.P.	2002	Strengthening of old suspension bridge.
24.	Armin P.	2002	Actual ship impact analysis.
25.	Cem Topkaya	2003	Erection stress analysis of curved bridge during construction.
26.	Janjic D.	2003	Optimal sequence for tensioning of staycable.
27.	Daniell Wendy	2007	Improved finite element by manual tuning.
28.	Karbhari V. M.	2007	Analysis of a FRP encased concrete bridge pylon connection
29.	Dan M. F.	2008	Uncertainty Effects on performance of CSB

Dynamic analysis is required to have an idea of bridge behaviour under seismic / wind condition. Rajaraman (7) developed analytical model for, non-linearities for geometry sag in cables etc . Analysis is also oriented to study impact due to moving loads, flutter, buffeting, to find out critical wind velocities as suggested by Namini et al.(8). Wang et al(9) studied dynamic response of a bridge to a moving vehicle Khalil (10) presented time dependent effect of creep and shrinkage of concrete for prestressed concrete Cable-stayed Bridge. Large amplitude vibrations of cables due to parametric vibration caused by plying vehicles are studied by Royer et al (11).Bhagwat et al.(12) Introduced the dynamic performance of straight and curved cable stayed bridge. Au F et al (13) presented in his work various modelling techniques for determination of natural frequencies and mode shapes of CSB's Cheng S.et al (14) compared numerical techniques for 3D flutter analysis of CSB's. ". Kim Ho-Kyung et al (15) published his work on Geometrically Nonlinear Buffeting Response of a Cable-Stayed Bridge. Gattullia Vincenzo et al (16) presented his work on One-to-two global-local interaction in a cable-stayed beam observed through analytical, finite element and experimental models. Chen Xinzhong et al (17) contributed new insight to Multimode Coupled Bridge Flutter. Ruiz-Terana A.M et al (18) found out Dynamic amplification factors in cable-stayed structures. Magalhaes et al (19) submitted the Challenges in the Application of Stochastic Modal Identification Methods to a Cable-Stayed Bridge. Gattulli et al(20) discussed cable dynamics. Bruno D(21)

studied dynamic impact response to moving load on long span CSB's. Caicedo et al(22) published comparative study of modelling techniques adopted for dynamic analysis of CSB's.. Ceballos(23) worked for determination of the axial force on stay cables accounting for their bending stiffness and rotational end restraints by free vibration tests. Fujino Yozo(24)] formulated Design Formulas for Damping of a Stay Cable with damper. Galvın P.(25) Worked on Dynamic analysis of a cable-stayed deck steel arch bridge. Wang et al(26) Studied on nonlinear analysis of a highly redundant cable-stayed bridge.

Table 3: Research Papers:: Dynamic Analysis Procedures for CSB's (In Brief)

Sr. No.	Researcher	Year	Contents
1.	Felippa	1974	3-D net as finite element.
2.	Mondkar	1978	Iterative procedure for non-linearity.
3.	Louis	1979	Non-linear problem solution using incremental algorithms
4.	Sehrffler	1983	Langrangian approaches for suspension bridge
5.	Khalil	1983	Time-dependent effect
6.	Yoshiaki	1984	Experimental work on dynamics
7.	Holger	1986	Aerodynamic stability for Box girder
8.	Shantaram	1988	Simplified equivalent modules for nonlinearity
9.	Desai Y.M.	1988	Pretension incline cable with geometric nonlinearity
10.	Abdel Ghaffar	1991	Geometric and material nonlinearities
11.	Abdel M.	1991	First four mode shapes for bridge
12.	Wang	1992	Moving vehicle dynamic for bridge
13.	Virote Boonya	1994	Analytical method for lateral torsional buckling of girder
14.	Ashmawy	1995	Non-linear dynamic analysis
15	Tom Irvine	1999	Vortex Shedding dynamics
16.	Weixin Ren	1999	Material non-linearity importance
17.	David	2000	Aerodynamic flutter stability analysis
18.	Main J.A.	2001	Aerodynamic study
19.	Au F. T. K.	2001	3-D mode shapes and resonance of bridge
20.	Fryba	2001	Experimental work on dynamics for foot bridge
21.	Pao Hussi	2002	Mode shapes for asymmetric bridge
22.	Das A.	2003	Surface roughness effect on dynamic for bridge
23.	Soyluk	2004	Random vibration method.
24.	Shumichi	2004	Pedestrians synchronized vibration analysis for bridge
25.	Shah N. D.	2006	Dynamic analysis of Spread Pylon.
26.	Wilson J. C.	2007	Dynamic Vulnerability study.
27.	Zhou H. J.	2007	Adjustable Fluid damper with shape memory alloy(SMA).

Table 4 :: Research Papers :: Seismic Analysis of Cable-stayed Bridges (In Brief)(6)

Sr. No.	Researcher	Year	Contents
1.	Kajita	1973	Basic Lateral Load Analysis & Mode Shapes for Plane Frame.
2.	Baron and Lien	1973	Uni Directional Earthquake Excitation.
3.	Nicholas	1974	Five Mode of Unsymmetrical Bridge.
4.	Zung Ah. Lu	1979	Shaking Table Results Compared With 3D Analysis.
5.	John Fleming	1980	Linear and Non-linear Seismic Responses.
6.	Knox	1984	Seismic Deflection Considering Soil Effect.
7.	Abdel	1991	Base Isolation for bridge.
8.	Wyatt	1991	Energy Dissipation and Damping Ratio.
9.	Filiatrault	1993	Post Earthquake Analysis.
10.	Kazuhiko	1993	Damping Ratio for Different Configuration of Bridge.
11.	Ali	1995	Elastomeric Bearing for Controlling Seismic Vibration.
12.	Xu Y. L	1999	Cable Vibration Equipment.
13.	Wei-Xin-Ren	1999	Kobe Seismic Time History Analysis.
14.	Tuladhar	1999	Different End Conditions for Seismic Analysis.
15.	James	2000	Seismic Analysis of Curved Cable-stayed Bridge.
16.	Said Allam	2000	Multi Component Seismic Excitation.
17.	Chang	2001	Finite Element Model Study.
18.	Floren	2001	Earthquake Occurrence Probability Analysis.
19.	Abolhassan	2001	Curved Cable Stayed with Inclined Pylon "Tripod" Effect.
20.	He W. L	2001	Resulting Semi Active Stiffness Damper for Bridge [RASAD].
21.	Michale J	2003	Lead Rubber Bearing (LRB) Bearing for Bridge.
22.	Jung	2003	Magneto Rheological(MR) Fluid Damper for Bridge.
23.	Jangid	2003	Time History Analysis with Viscous Fluid Damper.
24.	Gentile	2004	Mode Shapes for Curved Cable Bridge.
25.	Chang K. C	2004	Post-Earthquake Analysis.
26.	Lin J. H	2004	Passage of P-wave from Cable, Pseudo Excitation Method.
27.	Soyluk	2004	Seismic Analysis with Different Soil Conditions.
28.	Vassilis L	2005	Soil Structure Interaction with Time History.
29.	Kwan Soon P	2005	Fuzzy Supervisory Control (FSC) for Vibration Control.
30.	Siringoningo	2006	Double Curved Cable Bridge Seismic Analysis.
31.	Fung Lin H	2007	Digital Simulation for M. R. Damper.
32.	Wilson	2007	Seismic Vulnerability During Construction.
33.	Einde	2007	FRP Encased Pylon, Carbon Shell Edge Girder.
34.	Daniel	2007	Effect of Cable Removing for Repair, subjected to Seismic Load.
35.	Cai	2007	New Tuned Mass and Magneto Rheological Dampers.

III-.SUSPENSION BRIDGE (SB)

A suspension Bridge is a type of cable supported bridge which comprises of basic structural components as shown in **Fig 2** below

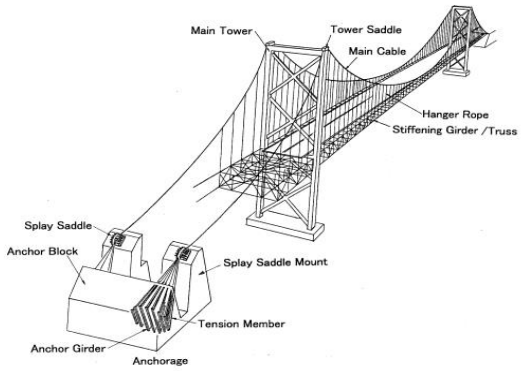

Fig.2 :: Suspension Bridge-Structural Components(27)

The roots of the suspension type of bridge were penetrated a long back in history. The present day suspension bridge apparently began in the 18th century when the improvisation of the structural system for the bridge and the iron manufacturing started extensively and comprehensively. Today, it is evidently acknowledged that, the suspension bridge is most appropriate sort for bridges of very long-span and really speaks for 20 or more of all the longest span bridges on our Mother Earth.

The merits of adopting SB can be summarized as

- High Up - Build Possible
- Over-cross Great Span (Lengths)
- Simple Construction
- Flexibility may lead to an added advantage too

- Cost effective

The demerits of adopting SB can be summarized as

- Soft Ground Issues
- High Flexibility(Too Flexible)
- May not support High Traffic may lead to problems

Wenliang Qiu et al (2014)(28) presented their work on the study towards the responses of a self-anchored suspension bridge to breakage of hangers.In his parametric study they incorporated various factors such as flexural and torsional stiffness of the deck girder, flexural stiffness & sag to span ratio of Main cable, wigth of structure , span, distance of hangers and breakage time of hangers.etc

Suleyman Adanur et al (2013) presented construction stage analysis, using SAP2000 using time dependent properties of concrete and steel in addition to geometric non-linearities on Humber Suspension Bridge, England.

John Sun et al (2004)(29) With extensive comparative studies on numerous alternatives, the new looping cable anchorage system suggested and recommended for the final design of the west anchorage of the self-anchored suspension span for its structural efficiency and dimensional compactness. This paper describes major design issues, design philosophy, concept development, and key structural elements and details of this innovative suspension cable anchorage system.

.**ZHANG Xin-Jun (2004)**(30) presented that the aerodynamic stability of long-span suspension bridge under erection, particularly at early erection stage, is more problematic than in the final state. Further, the sequences of pylons and the deck erections (non-symmetrical) add to the aerodynamic stability for the deck erection of long-span suspension bridges, particularly at early erection stages

IV-CABLE-STAYED SUSPENSION HYBRID BRIDGE(CSSHB)

As clearly seen in pictorial presentation in Fig 3, below, by combining both the system of cable supported bridges, innovative CSSHB can be formulated to ascertain achievement of following advantages

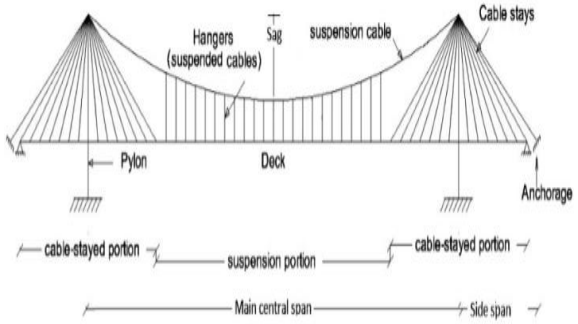

Fig.3 :: Cable Stayed Suspension Hybrid Bridge (CSSHB)(27)

1. The tensional forces developed in the main caternary cable(s) gets considerably reduced owing to shortening of the suspension portion when compared to the suspension bridge with the same span length.
2. The shortened/reduced suspension portion in main span results in reduced construction costs of the main cables, massive anchors; eases out to a greaqt extent the difficulty faced during construction in/under water, and therefore makes it possible to build in the soft soil foundation also.
3. Simultaneously the portion of cable stayed portion too is shortened when compared with CSB of same central span; and this reduction,yields optimisation in form of shortened height of Pylon tower needed, cable stay length(s) and thereby the axial forces developed in the stiffening girder i.e the deck.
4. The combination of CSB and SB portions resulting CSSHB have beenproved to be providing better wind/flutter stability owing to the fact that cantilevers are far shortened while process of erection/execution is underway

Thenceforth, Hybrid cable-stayed suspension bridge , (now onwards CSSHB) presents a better and more lucrative alternative for bridge systems which adopt cable supported systems garnering long to super long spans.
The cable-stayed suspension hybrid bridge is a structural system of very great flexibility and susceptible to service loads and dynamic actions. Therefore, static and dynamic performance of bridge is to be carried out. The literature for mechanics of Hybrid Bridge is discussed below.
Zhang Xin-Jun (2007)(31) presented the mechanics performance including the static and dynamic characteristics of cable-stayed suspension Hybrid Bridge. The aerostatic and

aerodynamic stability is investigated by 3D nonlinear analysis and shows that as compared to suspension and cable-stayed bridge, the cable-stayed suspension hybrid bridge has greater structural stiffness, less internal forces and better wind stability.

Zhang Zhe et. al. (2009)(32) *discussed* the limit span of self-anchored cable-stayed suspension bridge. The limit spans of self-anchored cable-stayed suspension bridges with concrete girder or steel girder under vertical static load were discussed in detail based on the material strength and commonly used materials. In order to get a longer span the measures suggested by the author were increased rise-span ratio, use a larger height-span ratio, enlarge the ratio of stay-cable segment length, expand main girder cross sectional area, reduce secondary dead load etc.

Zhang Zhe et.al. (2010)(33) presented a static analysis of a self-anchored cable-stayed-suspension bridge with optimal cable tensions. Author proposed two-stage approach to obtain the reasonable dead-load state, which derived from a nonlinear FEM and constraint relaxation quadratic programming method. Finally, through analysis of the Zhuanghe Jianshe Bridge, design problems that require special attention were pointed out and a reference basis for further application and design of self-anchored cable-stayed-suspension bridges were provided.

Lonetti P. & Pascuzzo A. (2014)(34) published a numerical model for considering the damage and failure behaviour on the cable system, which can be utilized for obtaining the response of hybrid cable-stayed suspension bridges subjected to moving loads. Parametric studies were conducted with the purpose of investigating the vulnerability of the structure against damage and complete failure phenomena produced in the cable system by means of comparisons between damaged and undamaged bridge configurations

For long span cable supported bridges, the geometrical nonlinearities are due to large deformation, cable sag and beam column interactions under dynamic loadings like wind and earthquake. Aerostatic and aerodynamic forces are the predominant forces acting on the bridges. Some of the researchers have worked on aerodynamic stability analysis of cable-stayed suspension Hybrid Bridge, the literature is presented here for work carried out yet.

Zhang Xin-Jun et. al. (2005)(35) discussed the effects of design parameters such as the cable sag, length of suspension portion, cable plane arrangement, subsidiary piers in side spans, the deck form, etc. on the aerodynamic stability of the bridge based on analytical investigation. The authors suggest from the analysis carried out that the short suspension portion in main span is aerodynamically favorable.

Zhang Xin-jun (2006) explained the effects of the geometric nonlinearity of bridge structures and the effects of nonlinear wind-structure interaction, method and its solution procedure of three-dimensional nonlinear flutter stability analysis of a cable-stayed- suspension Hybrid Bridge. From the analysis of bridges, design parameters that significantly influence on the flutter stability were pointed out, and favorable structural system of the bridge is also discussed based on the wind stability.

Zhang Xin-jun et. al. (2008)(36) investigated the wind stability by analyzing a cable- stayed-suspension hybrid bridge. The effects of design parameters were investigated. Utilizing 3D nonlinear aerostatic and aerodynamic analysis, and based on the wind stability, the optimal values of these design parameters were discussed.

Yong Gao et. al. (2009)(36) presented the seismic performance analysis and design optimization of a self-anchored suspension bridge. Based on the preliminary design of the bridge, a finite element model has been built by author for performing structural dynamic analysis. For time history analysis of the bridge subjected to seismic excitation, generatedartificial site-specific earthquake waves were adopted as the ground motion input. Nonlinear time history analysis was performed for the bridge.

Mu Y N et.al. (2009)(37) discussed the dynamic characteristics and seismic responses of self-anchored cable-stayed suspension bridge. The research work covers the natural vibration frequencies and principal modes of the bridge. With structural geometric nonlinear factors considered, the artificial earthquake wave was input from longitudinal, transverse and vertical directions respectively to get the response time histories of the internal force and displacement of control-section such as main beam and tower

Jing Qiu et al, (2010)(38),presented his work on ―Analysis of Structural Parameters of Cable-Stayed Suspension Bridges [15]**||** and

analysed a 1800 m CSSB to investigate systematically the influence of various principal structural parameters; such as rise-span ratio, the suspension-to-span ratio, the constraint condition of the stiffened girder, the number of auxiliary piers at side spans; on the static and dynamic behaviour of bridges

Sevalia G. et al,(2016)(27), submitted his doctoral work on -Effect of Geometrical Aspects on Static & Dynamic Behaviour of CSSHB [21]||, in which he elaborated on effects of various geometrical aspects such as side span ratio, lateral spread of pylon tower, sag to span ratio etc on a 1400m main span CSSHB

Gabra J H et al (2019)(39)**,** has submitted their work on respeonse of a 318+1400+318 long CSSHB to conclude on the effect of Pylon Tower on response of the CSSHB.

Gabra J H et al(2021)(40)**has** submitted in form odf a lecture notes the response to siesmic effect on CSB with different cable systems

CONCLUSIONS

During the last decades, many researchers have tried to propose proper procedure for calculation of an optimal configuration of bridge. The research work covers the natural vibration frequencies and principal modes of the bridge. Hence, the current work is committed towards the nonlinear static and modal analysis of cable-stayed suspension Hybrid Bridge.

CSSHB's have been analysed statically as well as dynamically using various geometric parametric variations such as Sag to span ration, suspension to main span ratio, intermediate side span supports, pylon shape, stay cable patterns, use of overlap and different material for deck girder in cable stayed and suspension span etc.he main cables as well as the suspension portion in cable-stayed suspension hybrid bridge. From the literature it is found that the work related to the static and dynamic analysis of cable-stayed suspension Hybrid Bridge with variable length of suspension portion is still inadequate.

From the available literature, it is found that the work related to the seismic analysis of cable-stayed suspension Hybrid Bridge is very limited. The long span cable supported bridges are also viable to excitations due to dynamic actions of the seismic events. So, special attention is needed towards the seismic analysis of cable-stayed suspension Hybrid Bridge. Hence, the scope of work in seismic analysis of cable-stayed suspension Hybrid Bridge is great and the current work is devoted to time history analysis of CSSHBs

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