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Non-Linear Analysis of Cable Strayed Bridge using STAAD-Pro

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ABSTRACT: The interesting point of this investigation is to use STAAD-Pro to watch how a cable-stayed bridge moves in ways that aren't straight lines. The plan for the bridge is very long—541.8 m—with two 128.1 m-long side spans and a main span that is 285.6 m long. It looks a lot like the US bridge Quincy Bayview in Quincy, Illinois. The deck's top is held up by several layers of stay wires that are set up in a half-harp shape and connected to each crosswise H-shaped beam. These eighty stay cables keep the whole bridge deck stable. The cross-section of a bridge deck is usually made up of a 0.23-meter-thick prefabricated concrete deck that is 14.20 meters wide. It is held together by two main steel girders and floor steel beams that are evenly spread. We use the STAAD-Pro tool to look at the pylons, which are made up of two concrete legs connected by two struts. This tool lets you see how the bridge reacts to changes in low, medium, and high frequencies over time. They are divided into three groups based on the ratio of the fastest ground speed to the fastest ground acceleration (PGA/PGV). The study findings are shown and talked about for both normal and odd reinforced concrete buildings. The study's goal is to help people better understand how cable-stayed bridges behave in non-linear ways when they are subjected to different levels of earthquake stress. This will then lead to better design suggestions for these kinds of structures.

I. GENERAL



Fig.1 Cable stayed Bridge

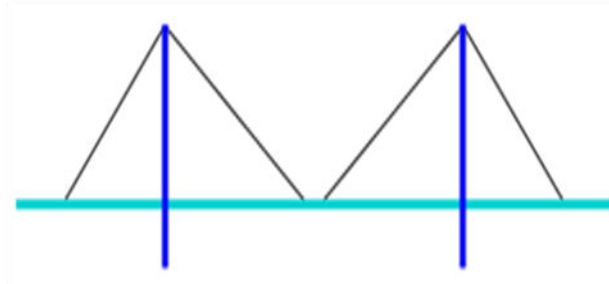
A lot of individuals are not aware that cable-stayed bridges have been in use for more than four centuries [1]. Many initial cable-stayed bridges also had suspension cables. Moreover, some of the first cable-stayed bridges used suspension cables [2].

The utilization of cable-stayed bridges has only recently garnered attention, notwithstanding their inception dating back to the 1970s [3]. This surge in popularity can be attributed to advancements in materials and technology that now facilitate the efficient and economical traversal of medium to large spans (ranging from 300 to over 3000 feet)[4]. Additionally, cable supports possess the capability to bear supplementary structures, thereby enabling the development of multi-span bridges extending several kilometers in length[5]. In the early 1900s, Mr. Eugene Freyssinet in France devised a post tension system that is a derivative of the unique cable stay bridge system of the modern-day Indian River Inlet Bridge[6]. The study examines the bridge's reaction to various loading circumstances, including static and dynamic loads, to determine its structural integrity and performance under diverse scenarios [7]. Additionally, the

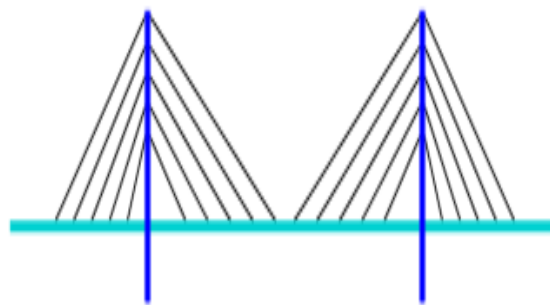
research explores the effects of geometric nonlinearities and material nonlinearities on the bridge's behavior, providing valuable insights for optimizing design parameters and improving overall safety and efficiency[8].

1.1 Types of Cable strayed Bridge

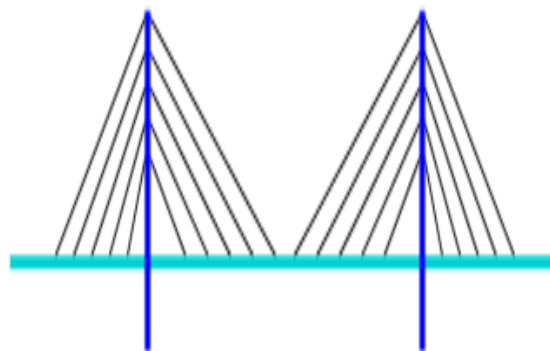
There are four major classes of rigging on cable-stayed bridges: mono, harp, fan and star



Mono design



Harp design



Fan design



Star design

II. METHODOLOGY

2.1 Ground motions and linear time history analysis

The reactions of the building at discrete phases of time are identified through dynamic analysis, which employs time history analysis from a discretized record of synthetic time history [9]. Only the most important reactions to the relevant parameter are selected when several time history analyses are conducted [10].

Analyzing the structure's dynamic response at each time step while its base experiences a certain ground motion is called time history analysis [11].

When considering more general mode implications is unnecessary, static approaches are a good fit. Structures that are succinct and uniform often benefit from this [12]. Dynamic approaches are required for tall, torsionally symmetric, or non-orthogonal structures.

It is a multi-degree-of-freedom (MDOF) system that we study in linear dynamic analysis[13]. We utilize a linear elastic stiffness matrix and a related viscous damper matrix to describe the structure. We can easily fake earthquake data with time history analysis[14]. To find out about changes and forces inside a building, linear elastic analysis is used. It is better to use the linear dynamic method than the linear static technique because it lets you try more situations [15].

Linear dynamic analysis, which keeps a lot of phase information, is used to figure out the building's time domain reaction to ground motion. Only linear traits will be used in the evaluation [16]. To answer the motion equation for a one-degree-of-freedom system, you can't usually use math. This is because the equation isn't linear, the external force or ground acceleration changes randomly over time, or both of these things happen at the same time[17]. Numerical time-stepping techniques may be employed to address these issues when integrating differential equations.

To figure out how buildings will react to low, medium, and high-frequency ground movements during an earthquake, dynamic analysis is a must. Linear time history studies are done with the STAAD Pro software tools [18].

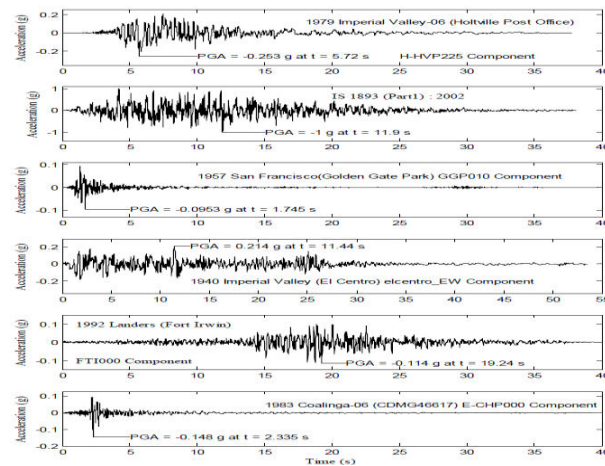
For both regular and irregular reinforced concrete constructions of two, six, and twenty stories, three-dimensional models are utilized [19]. After the linear time history study of important reinforced concrete buildings, the material factors, beam and column measurements, gravity forces, and the six ground motions listed in Table 4.3 are put into action. In Chapter 6, similar results are found for uneven reinforced concrete buildings[20]. In Chapter 5, the results of the linear time-history analysis are shown for regular structure.

2.2 Ground Motion Records

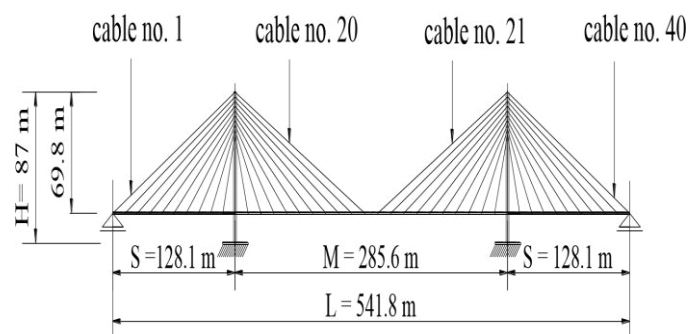
Earthquakes may cause buildings to collapse. The dynamic properties of ground motion include time, frequency, acceleration, velocity, and displacement at their maximum points [21]. The investigation of reinforced concrete structures' responses to seismic loading requires these dynamic properties. The slenderness of the structure, in addition to the magnitude, frequency, and duration of ground motion, determines its stability [22]. Twenty-three With respect to the frequency composition, which is the PGA/PGV ratio There are three types of ground motion recordings.

- 1) High-frequency content $PGA/PGV > 1.2$
- 2) Intermediate-frequency content $0.8 < PGA/PGV < 1.2$
- 3) Low-frequency content $PGA/PGV < 0.8$

Concrete Properties		Steel Bar Properties	
Unit weight (γ_{cc})	25 (kN/m ³)	Unit weight (γ_{ss})	76.9729 (kN/m ³)
Modulus of elasticity (EE_{cc})	22360.68 (MPa)	Modulus of elasticity (EE_{ss})	2x10 ⁵ (MPa)
Poisson ratio (ν_{cc})	0.2	Poisson ratio (ν_{ss})	0.3
Thermal coefficient (α_{cc})	5.5x10 ⁻⁶	Thermal coefficient (α_{ss})	1.170x10 ⁻⁶
Shear modulus (GG_{cc})	9316.95 (MPa)	Shear modulus (GG_{ss})	76923.08 (MPa)
Damping ratio (ζ_{cc})	5 (%)	Yield strength (FF_{yy})	415 (MPa)
Compressive strength (FF_{cc})	30 (MPa)	Tensile strength (FF_{uu})	485 (MPa)



III. PROBLEM STATEMENT



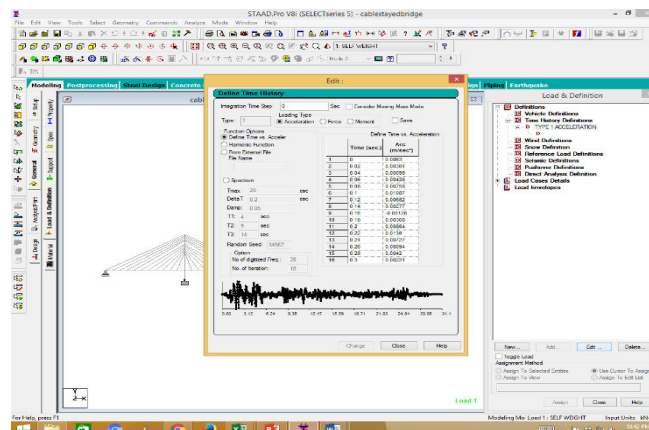
The Quincy Bayview Bridge in Illinois, United States, is similar to the bridge used for this study. While the two lateral spans (S) are each 128.1 meters, the main span (M) is 285.6 meters long. Therefore, Figure 1(a) reveals the bridge's entire length (L) as 541.8 meters [23].

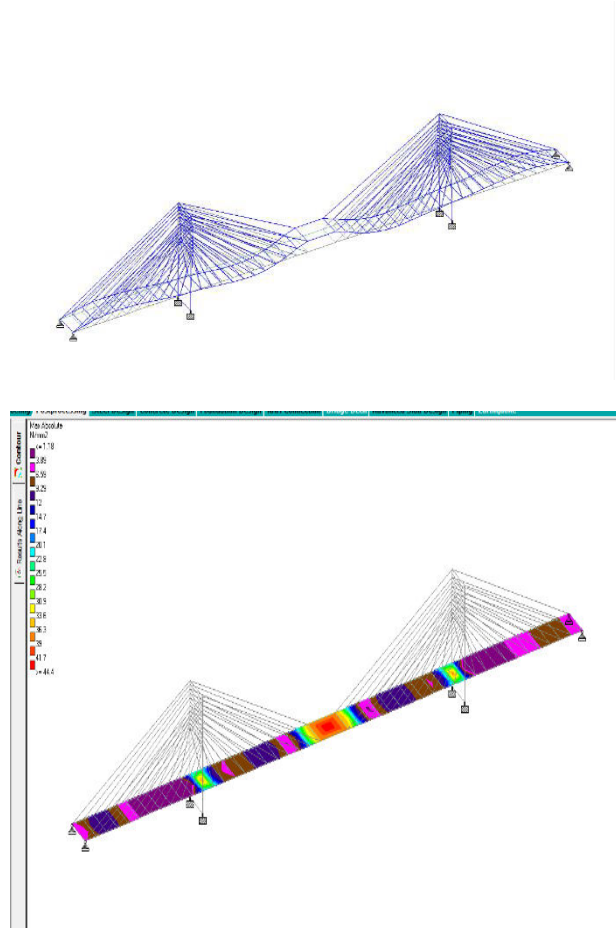
Two semi-harp planes of remain cables hold up the deck superstructure. Forty cables are attached to each crosswise H-frame pole. So, the whole bridge superstructure is held up by 80 cables, 40 for the main span and 20 for each side span[24].

The bridge is 12.2 meters wide between the cable centres and has two traffic channels. The bridge platform's standard cross-section (Figure 1(b)) is a 14.20 m-wide precast concrete deck that is 0.23 m thick. Two steel primary girders are used to reinforce the deck's exterior border. A network of floor steel beams that are spaced at regular intervals connects these girders. Nine and a half meters separate each set of floor steel joists.

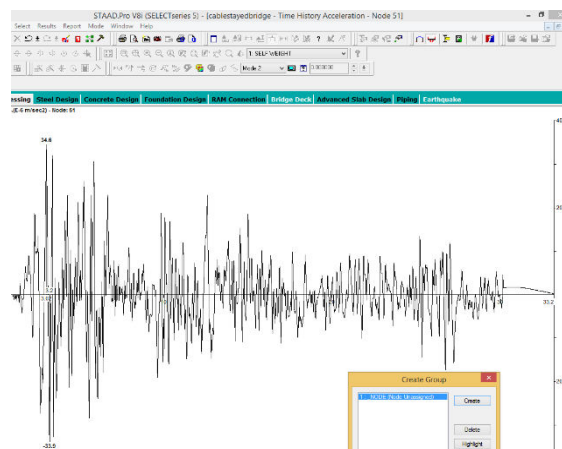
Two concrete legs joined by supports make up the pylons. While the bottom strut crossbeam supports the deck, the top strut crossbeam links the upper legs. A wall 1.22 m thick links the web-like structure created by the pylon's legs [25].
STAAD-Pro FEA modelling: The table reveals the qualities of concrete and steel bars. The STAAD Pro modelling of reinforced concrete buildings makes use of these materials. Concrete and steel bar properties as per IS 456[26].

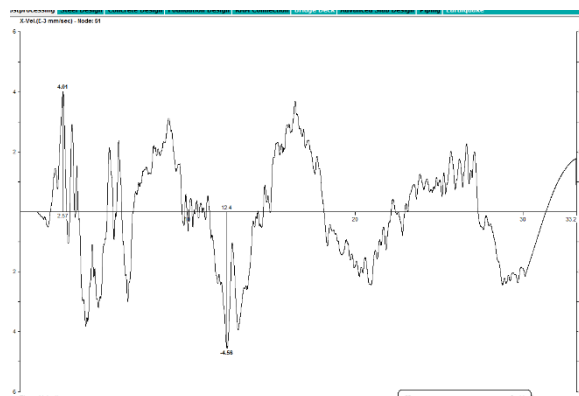
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Thermal coefficient (α_{acc})	5.5x10 ⁻⁶	Thermal coefficient (α_{ass})	1.170x10 ⁻⁶
Shear modulus (GG_{cc})	9316.95 (MPa)	Shear modulus (GG_{ss})	76923.08 (MPa)
Damping ratio (ζ_{cc})	5 (%)	Yield strength (FF_{yy})	415 (MPa)
Compressive strength (FF_{cc})	30 (MPa)	Tensile strength (FF_{uu})	485 (MPa)





IV .RESULT AND DISCUSSION





V. CONCLUSION

The STAAD-Pro program is used in this study to look at the nonlinear parts of a cable-stayed bridge like the Quincy Bayview Bridge in Illinois, USA. The main span of the bridge is 285.6 meters long, and the two side spans are each 128.1 meters long. It's 541.8 meters long all together. Eighty cables are attached to H-shaped poles to hold the deck's upper structure. The upper structure is held up by two sets of stay cables set up in a semi-harp shape [27]. The seismic response of the bridge underground movements characterized by low, moderate, and high-frequency content is analysed utilizing linear time history methodology, as established by the PGA/PGV ratio. The purpose of this manuscript is to present improved design recommendations and to enhance the understanding of the nonlinear characteristics associated with cable-stayed bridges.

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