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Computational modeling of a historical truss bridge for structural health monitoring

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ABSTRACT: Aging of historical bridges, coupled with increasing traffic loads, creates a severe toll on protection of these cultural heritages. Thus, making a closer glimpse at the health of these structures by Structural Health Monitoring (SHM) has become growing demand as a reliable monitoring system. In SHM, computational modeling based on design details provides crucial dynamic characteristics of the structure, more importantly, can be used as a base model for field test, response assessment and damage detection of the structure. This study presents a historical truss bridge, “Kean Bridge” of Bangladesh and its high fidelity computational model using ANSYS for SHM applications. First, a detailed description of its historical evolution along with its structural configuration is addressed. Then, an extensive 3D dynamic analysis is carried out to obtain corresponding modal properties of the structure. This work primarily presents the phase of analytical investigations for correlation of field test SHM data to the model in future work.

1 INTRODUCTION

During the last decade, Bangladesh has achieved a momentous progression in her socio-economic development in spite of the global economic recession. To sustain this growth rate, the country requires a robust transportation network to spread communication through the root level guaranteed by a strong infrastructural backbone. According to the World Bank, to create this framework congruent with her growing population, Bangladesh needs between $36 and $45 billion of investment. Figure 1 represents her civil infrastructural development cost in the last 10 years, from $1 million in 2009 to about $3 billion in 2018. However, a closer look reveals that 41% of the total development budget actually begot from maintenance rather than development. Hence, state-of-art maintenance systems can contribute significantly to maximize the investment for development ergo, ensuring definitive outcomes for the nation.

Geomorphology of Bangladesh is dominated by the Ganges-Brahmaputra-Meghna low-lying delta system and its hundreds of tributaries, distributaries as well as other water bodies. Thus, Bridges are not only ubiquitous in the transportation framework of the country but also critical to her economic vitality. After independence, rapid increment in the number of bridges from 1,112 to 18,356 in 2013 (RHD 2018) corroborates their importance to socio-economic welfare in general. Meanwhile, the necessity for accurate evaluation of possible life cycles of the continuously aging bridges has transformed into a growing demand with time, especially if the original structure is required to be reconstructed, repaired or substituted for a newer one. Many bridges of Bangladesh have important historical value and aesthetic properties of former times (for example, see Amin & Okui (2015) or, Nuruzzaman & Siddique (2015)). Their design loads are substantially limited to simple static hand calculations, which are inevitably different from the imposed commuter loads of the present day, moving at a faster speed. Situation is further complicated because of their continuous exposure to natural calamities (e.g. Earthquakes, Cyclones etc.) or severe environmental conditions, which influence the bridges to vibrate at elevated dynamic frequency, even leading them to receive critical damage (Banik & Das 2020). Since they are treated as national treasures so, preservation is more desirable for these historical constructions. Besides, for a developing country like Bangladesh, reconstruction of these bridges are usually not executed, mostly due to budget constraints. From this point of view, it is advisable to deal with their remediation while maintaining their original functional and aesthetic properties as well as ensure their continued safe operation. In other words, to harness the maximum benefit of investment and also to ensure safety, there exists an obvious necessity to monitor the bridges under static and dynamic loads (Sobhan & Amin 2010).

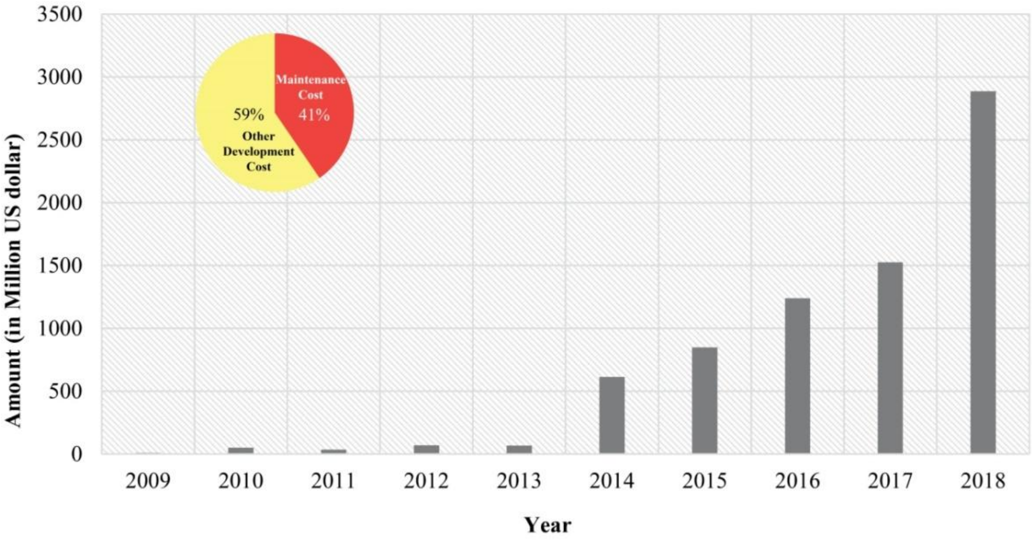


Figure 1. Infrastructural development cost of Bangladesh in last decade (data compiled from RTH 2019).

Nevertheless, in Bangladesh, maintenance of these bridges still handled in a jumbled and myopic attitude. Customarily, most bridges are inspected once every 5-10 years. Traditional forms of inspection techniques practiced by officials (RHD 2018) are cumbersome yet, the dominant method for assessing cracking, corrosion or, other forms of deterioration. It is largely biased, having heavily based on the knowledge and expertise of the participator. Moreover, visual inspection is harder to implement – especially on inaccessible positions, and could even prove dangerous for the inspectors to perform on risky locations. It is thus imperative that with an automated health monitoring system installed on the structure, performance can be monitored and problems can be detected early and corrected, ultimately saving maintenance time and money, without posing questions on the essential expertise or the possible health threat.

In this case, for safety and serviceability assessments of operational civil infrastructural systems, Structural Health Monitoring (SHM) has become quite acknowledged (Banik & Das 2019). Particularly Vibration based SHM, for its nondestructive and noninvasive nature, has recognized to be appropriate for historical or damaged structures that are potentially unsafe under other test environments. Over the last 20 years, significant aspects of vibration based SHM have been explored in either lab experiments or field testing, mostly focusing on analytical modeling, applications of sensing technologies, data acquisition systems and system identification algorithms as well as model updating. More recent inclusion like – digital twins: a fusion between statistical analyses with structural assessment by processing a large quantity of data to present real time information of the physical twin, is a tendency in the future. To fulfill this task, a detailed realistic computation model can prove an essential tool. Natural frequencies and corresponding vibration modes obtained from the analytical model provide significant modal properties representing the dynamic performance of the structure. An accurate analytical model along with those Eigen properties can serve as the foundation for further specialized procedures, i.e. optimal sensor placement, structural deficiency (e.g. damage) localization and quantification, condition assessment, response prediction under diversity of loadings or conditions, and so forth.

The current article is a part of an ongoing research effort to implement a practical SHM system on a historical structure named Keane Bridge situated in Sylhet, Bangladesh. Especially the issues of its historical evolution and numerical modeling for further application in SHM procedures have been discussed here. Firstly, to provide some insight, a detailed historical background and current condition is presented. Thereafter, the primary field investigation along with the structural configuration of the Keane Bridge is addressed. Finally, an extensive 3D finite element model (FEM) of the main span of the bridge is created using ANSYS and modal analysis is carried out to analyze the dynamic characteristics of the structure.

2 KEANE BRIDGE: A CULTURAL HERITAGE

The Keane Bridge, or Surma Bridge – as the locals call it (Azad 2016), is one of the momentous landmarks of Bangladesh made by the British Raj. From 18,356 bridges and culverts situated in Bangladesh, Keane is the third longest bridge of its kind (RHD 2018) and is considered as one of the most important key elements in the northeastern transportation network of her. Carrying Road N208 (Hasan & Ahmed 2013), otherwise known as the Dhaka-Sylhet highway (actually, Moulvibazar-Rajnagar-Fenchuganj-Sylhet road), this bridge serves as the major link over Surma River connecting Varthokhola to Bandar, center of Sylhet metropolitan. It is situated on the South Eastern side of Ali Amjad's Clock (constructed in 1874), beside theatre buildings, about 230 meter from the Sylhet Circuit House and 450 meter North West from Sylhet railway station; geometrically on 24.887970°N, 91.867934°E.

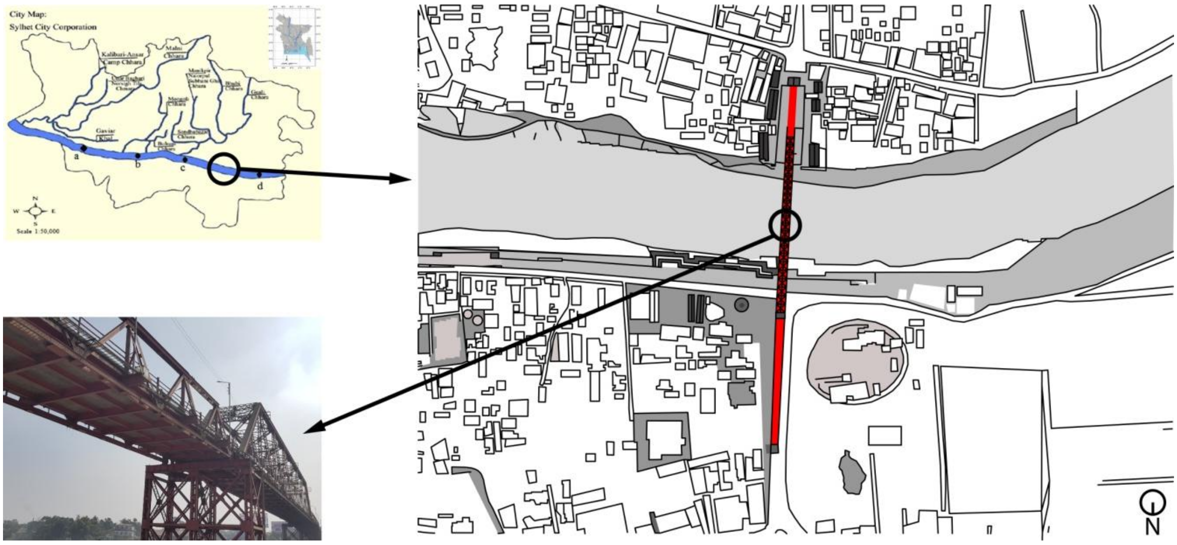


Figure 2. Location of Keane Bridge on map (inset: Sylhet city and perspective view of the bridge).

2.1 *Background*

To construct Keane Bridge on the river Surma, several motivations have known to exist. Firstly, from ancient times Sylhet remained as one of the most important spiritual, cultural and administrative centers, especially after declaration as a district by the Mughal Empire. During British India, it gained further attention due to the emergence of a global product – Tea. The first tea garden established by the East India Company resides in Sylhet is still the largest one in the Indian subcontinent (SCC 2020). However, creation of an exclusive province to ensure interests of tea planters, as well as efficient use of state tools, was long demanded. As a result, taking account of the financial viability, the British government merged Assam and Sylhet to create North-East Frontier, also known as Planters' Realm (Hossain 2009). This area produced a large quantity of tea and different agricultural crops, which was later transported through Assam-Bangla Railway to port city Chattogram for export. But this process entailed a lot of time and economic problems. For example, a single journey from Shillong to Sylhet required about 35 hours (Gassah 1984). Besides, the travel comprised a mixture of roads, rails and steamers; turning it much more tiresome than it was actually. So to ease the weary communication between these areas, the Assam government planned to build a bridge on Surma connecting Sylhet to the port city via road.

This idea further accelerated for two more reasons. At that time, Sylhet was undergoing a remarkable transformation for the quantity of inward immigrants it was facing from the hinterland. Earlier, Sylhet was one of the low-density districts of Bengal in terms of population. However, after capitalist investment followed by a rapid expansion of the tea industry, a larger workforce was necessary to meet the higher demand for labor. But Sylheti laborers had several social stigmas for working in tea gardens as 'Coolies' or on roads, i.e., apprehension of sub-human life, nominal wage, affluent antecedents etc. Moreover, after the emergence of tea as a global product, it was the most valuable item to export for the British government. At that time, goods from Assam and Sylhet were transported to Kolkata through the Surma. Since the local people of Sylhet had a tradition of seafaring, they mostly worked on this sector. After the establishment of the Assam-Bangla Railway, it was quicker and easier to move goods through rail rather than boats. So, most of the local people started new lives as lascars of ships, which gave them both high wage and fulfilled their curiosity to travel the world. Therefore, an acute shortage of laborers was observed in the Planters' realm (Hossain 2009). Situation changed in the late nineteenth century when migration toward eastward gained momentum as reflected by the sharp increment in population density. Decreased income in neighborhood districts for ecological disasters like famine, drought along with poverty and landless condition, herds of people were coming from different parts of Bangla in search of jobs. Indentured emigration from overseas colonies resulted from rational and deliberate choices by laborers prompted by the hope of a better future, elusive dream of high payment and lighter work. For most migrants, employment in the tea gardens held a flickering hope to escape from debts, failing crops, poverty, unemployment and family problems. However, apart from working as 'Coolies' or tea-garden laborers, some immigrants also focused their attention on cultivation, extending the agrarian society of Sylhet. Increased mobility of labor made possible by the railway allowed the stricken people in times of drought to migrate to developing areas for work. Railways were quite beneficial as the laborers arrived three or more days earlier than they would otherwise, when traveling all by steamers. Thus, the government inferred that a bridge on Surma would attract more people from the Bangle to work in the tea gardens by availing advantage of a continuous roadway.

Finally, during 1933, Governor of Assam Sir Michael Keane planned a visit to Sylhet after the inauguration of Shillong-Jaintapur Road. In that period, the province of Assam was administrated under the Assam legislative assembly by a diarchy system. Several of the ministers in the assembly was from Sylhet, especially the education minister Moulvi Abdul Hamid and Rai Bahadur Promode Chandra Dutt. Sir Keane possessed a liberal outlook and was very sympathetic toward Indian aspirations (Shibly 2011). As a result, after getting suggestions from the ministers, inspecting the distress of the people, and consulting with the Assam legislative assembly, the governor announced to construct a bridge on the Surma River following his visit. Sir Michael Keane had a very charming personality, worked for the people and urbane taste (Kissane 2020). He identified himself whole-heartedly with the interest of the province over which he was called upon to rule (Sharma 2006). Therefore, the bridge was later named after him as memorabilia of his wise decision toward his province.

2.2 *Construction and Evaluation*

The British government initiated construction work of Keane Bridge from 1933 under the supervision of the North-East Frontier Railway. The bridge was designed and fabricated by Braithwaite & Co. Engineers Ltd. (Now known as Braithwaite U.K.), which was a public company responsible for fabrications of other major structures like– Hardinge and later Howrah Bridge in British India. The steel sections required to build the bridge was shipped directly from Britain to Chattogram. It was opted for both northbound and southbound traffic, opened for the commuters in 1936, only two years before the second world war. At that time, about 5.6 million rupees were invested in constructing the bridge (Ahmed 2004). It was one of the most famous road bridges of undivided India (Ahmed 2004) and is still famous for its historical vibe and well-known attraction for the tourists.

Before the construction of the bridge, majority of Sylhet city was situated on the northern bank of the Surma River and the town was only extending toward that direction. Following the completion of Keane Bridge, the city also started extending southward. The bridge was built to provide improved infrastructure for Sylhet as the importance and prominence of the town grew.

2.3 *Historical Contribution and Repairing*

In early December of 1971, during the liberation war of Bangladesh, the Varthokhola side of the bridge was damaged by dynamites planned by the Pakistan Military, who was then besieged and trying to evade the surrender. After independence, the damaged parts were provisionally repaired with woods and bailey parts subsequently opened for plying of lightweight vehicles.

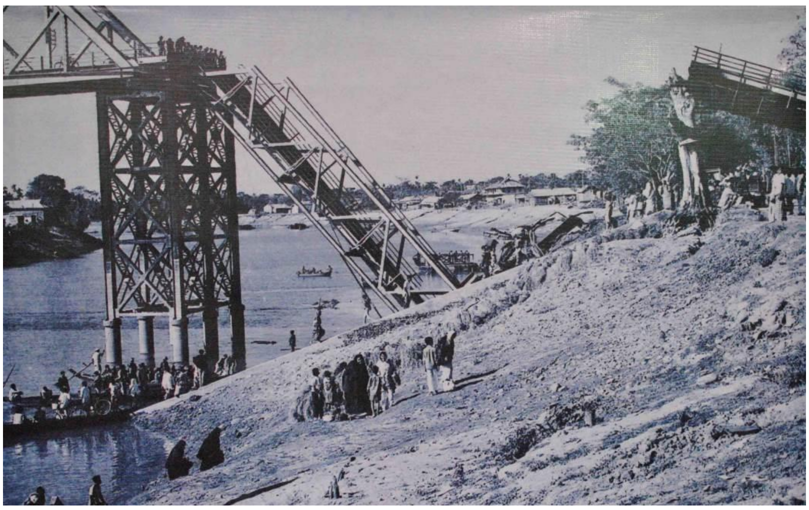


Figure 3. Dislodged approach road of the Keane Bridge during the Independent War (captured on 1972).

After resurgence of the country, in 1977 the deck and approach roads of the bridge were completely reconstructed with concrete and steel under the supervision of Bangladesh Railway. Then, till 1985 it served as the only bridge on Surma (Tappin, Jones & Khan 2015).

Currently, the Roads and Highway Department (RHD) is responsible for maintenance of the bridge, whereas the Sylhet City Corporation (SCC) authority takes care of it as a tourist attraction.

2.4 *Present Condition and SHM*

Among the five bridges present on Surma River, Keane Bridge is the busiest one (Ahmad 2019). Most of the lightweight traffics like Auto, Motor and Cycle rickshaws, motorcycles and pedestrians entering Sylhet from other districts, make their entrance through Keane Bridge. Therefore, it is called the 'gateway' of Sylhet. More than five thousand vehicles and pedestrians cross the bridge each day.

However, in the early 1900s, when hand calculations were the dominant means of analyzing structures, adherence to statically determinate types persisted. Besides, modern dynamic analysis methodologies and relevant codes and standards were nonexistent at that time. Thus, many of the bridges built on that era were characterized to withstand static and wind loads only. This bridge – like any other historic bridge in the world was not designed to carry the possible traffic loads that are commonplace today.

After 1978 due to transportation of the qualified natural stone of Sylhet, Keane bridge had been plied under heavy vehicular traffic, which was responsible for damages in the expansion bearing and introduced light vibration to the bridge. Following this, heavy vehicles were reduced to a minimum since 1980. After 1985, construction of the 2nd bridge on Surma was completed and heavy commuters were banned to enter in the bridge. Later, the increased vibration had convinced the authority to disband most traffics on the bridge. It has been surviving on refurbishment until now. In 2019, SCC has forbidden any kind of vehicles even Auto or motorized rickshaw on the bridge for conservation purposes and turned it into a pedestrian-only bridge (KKS 2019). However, for their multi-dimensional necessity, the people later protested and forced SCC to reopen the bridge to light traffic (Uddin 2019). Therefore, detecting and repairing the damages of the Keane Bridge has become a crying need of the hour for the safeguard of this nearly century-old cultural heritage of the city.

Analyzing the current condition, to detect the places requiring attention and prediction of possible lifespan, this historical structure demands a robust monitoring system corroborated by state of art computation techniques available in modern fields of science, which is the goal of this study.

3 VISUAL INSPECTION

Due to her geopolitical situation, Bangladesh has undergone a massive change after World War II, and Sylhet was not far from it. The partition of Bengal in 1947 and hereafter the Sylhet referendum severed Sylhet from Assam and merged it with Bangladesh. During British Raj, Assam Railway mostly commissioned important construction works initiated in Bangladesh, and so relevant drawings, details were vaulted by them. Hence, many significant data have gone extinct after the partition of Bangle. Further, the liberation war in 1971 has also influenced to abandon many drawings. According to officials from RHD, negligence of authority was also responsible for failing in retrieval of those documents. However, during 2004 a superficial survey was commenced on Keane Bridge by RHD as a part of nationwide bridge inventory survey (Farid 2004), where many necessary intricacies remain unnoted. Thus, to explore such details of the complicated geometry, a comprehensive inspection was necessary which was possible to be attained by visual inspection.

The whole inspection was planned to be carried out in two steps. One is for the establishment of baseline data and the other is for re-scrutinizing as well as check the quality of the collected information. A team of eight academic personnel was formed according to their experience to finish the task in two days. The inspection was carried out as per RHD's Bridge Inspection and Evaluation Manual and Bridge Inspector's Reference Manual of Ryan & Hartle (2012). Hand on inspection were performed for most of the truss members (AASHTO 2018).

During appraisal of the superstructure, most evaluations were conducted from road height, whereas from ground height conversely. The team utilized a list of specialized tools and equipment for this purpose. Firstly, to measure the span length, panel distances and confirming the dimensions of the bridge several 100 ft. Surveyors' tapes were used. Further, different truss elements, cross-sections and similar measurements were obtained with 3 ft. Steel tapes. However, when evaluating the thickness of members, accuracy was desired. Therefore, two Vernier calipers (RHD 2018) were used to measure those. A field notebook was carried on both inspections to create annotated sketches with necessary details along with a digital camera to record essential photographs. Finally, a standard GPS device was managed to calculate the geolocation of the bridge accurately.

Figure 4. Some photographs from the in-field inspections of the bridge.

3.1 *Superstructure*

The Keane Bridge consists of three parts – a single-deck truss bridge with one main span and two side approach roads. The main span is a through truss supported with fixed pinned bearings, whether the approach roads are of pony truss. The total length and width of the bridge are 1186 ft. (361.5 m) and 19 ft. (5.8 m) respectively, with an 18 ft. (5.5 m) carriageway (Farid 2004). The approach roads are relatively newer additions of the bridge, hence, their significance as heritage is smaller. Therefore, in this study, only the main span of the bridge was closely investigated.

The main span of this vintage bridge is 248 ft. (75.6 m) long and 19 ft. (5.8 m) wide, with a height of 31 ft. (9.45 m). It is a variation of Baltimore truss bridge with the appearance of a Bow, which was constructed entirely with iron steel (Amin & Okui 2015). The bridge has eight panels, all of them are equidistance, spanning a typical length of 31ft. Distance of consecutive sub-verticals is 31 ft. and consecutive sub-verticals to verticals measures 15.5 ft. The top chord and intermediate posts of trusses placed on either side of the deck are connected respectively with horizontal struts at top and sway struts at 20 ft., which are further coupled with a pair of sway bracings for additional stiffness. Similarly, pairs of lateral bracings were placed connecting successive verticals to resist supplementary lateral loads, which are continuous throughout the main span. However, discontinuity of sway strut and bracings can be observed at the hip verticals. All members of the bridge were connected using rivets on gusset plates rather than nuts-bolts or welding, which was a common practice at that time.

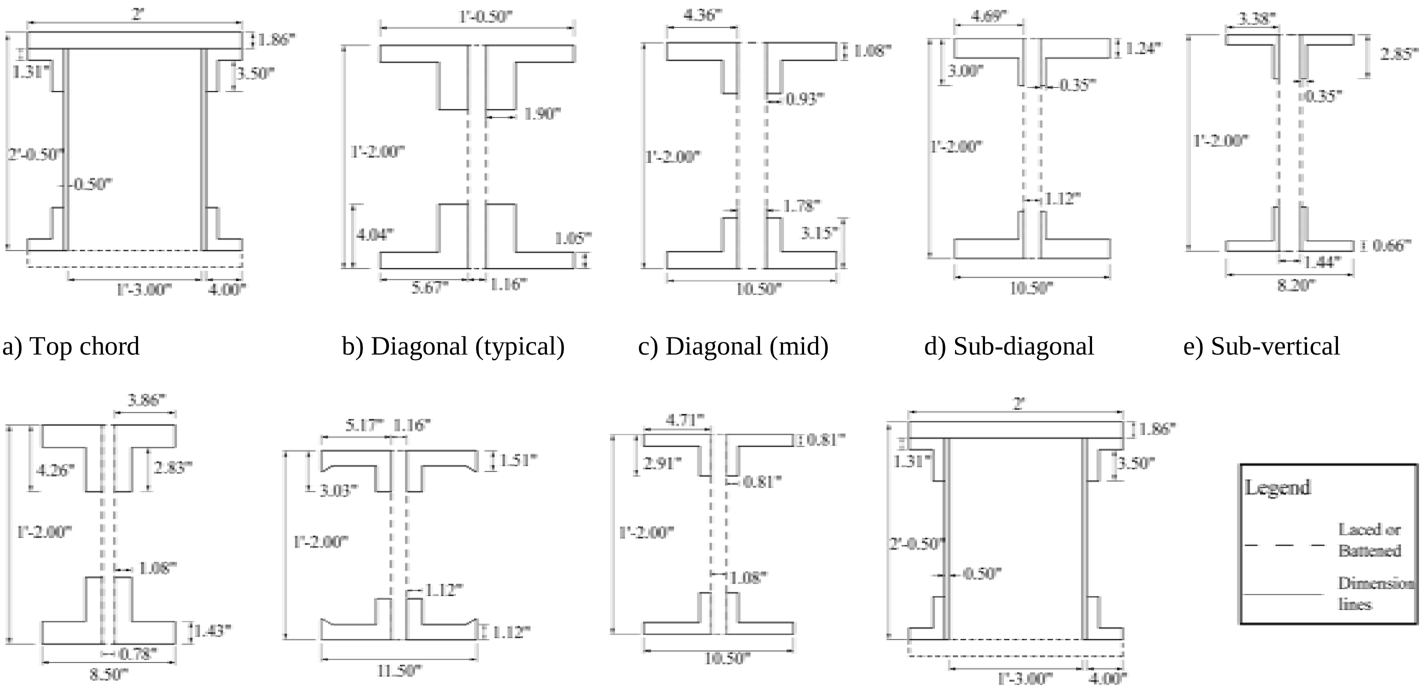
The deck of the bridge in concern consists of a reinforced concrete slab having 1 ft. thickness with 2 in. bituminous wearing course. The concrete slab is supported by two pairs of longitudinal stringers, maintaining a constant distance of 5 ft. center to center. The stringers are continuous and attached to the transverse floor beams with two angles riveted on either side. The bottom chords of the bridge are spaced on 2 ft. from the outer stringers. The steel floor beams are spaced 15.5 ft. apart, so that, loads coming on the verticals and sub-verticals can be transferred to the floor beams, which can be carried subsequently by stringers to the support placed on the four ends.

3.2 *Substructure*

The superstructure has steel plate bearings and is pin supported on all four sides. The supports are resting over a system of a stringer and two common caps. The system is situated at each end of the main span. Manufactured as a battened build-up section, the caps carry the loads through a group of columns in a rectangular trestle pier system constructed with iron steel. Adequate amount of angles are riveted with the caps to strengthen them. The pier has three longitudinal and three transverse bents, where two are placed along the width of the bridge, and the other is built perpendicularly. Additional lateral and longitudinal stability was provided by installing pairs of laced cross bracings at each bent. On the longitudinal bents, steel sills are located at intermediate positions. The total load is transferred by six columns to an equivalent amount of steel piles resting on the river bed. Presence of wing wall or conventional abutment was not detected (Farid (2004) also found similar); rather, the bridge end is sustained by earth.

3.3 *Cross Sections of the Main Span*

The entire main span is constructed with buildup sections from steel channels, angles or plates. The sections were further stiffened using lacings or battens along their length. To prevent buckling of vertical and horizontal members, all members expect top and bottom chords are V-laced. Whereas on end posts angles were used to provide lacings, plates were installed on other sections. The top and bottom chords were also battened with plates so that they could act as one section. Sections as measured in visual inspection are provided below:



a) Top chord b) Diagonal (typical) c) Diagonal (mid) d) Sub-diagonal e) Sub-vertical

f) Hip vertical g) Vertical (typical) h) Vertical (mid) i) Bottom Chord

Figure 5. Cross-sectional details of different members of Kean Bridge.

In summary, Keane is marked as one of the oldest bridges of Bangladesh, the emblem of Sylhet city from its inception. It not only transformed rural Sylhet into an urban one, rather stands as the witness of many historical incidents have taken place in the city. Though time has dilapidated the condition of the bridge, it remains at the heart of the buzzing city life. The cultural and historical importance of this bridge justifies the implementation of a long-term SHM system, so that possible actions can be adopted to minimize or mitigate both structural aging and accidental damages. Despite many efforts have been put earlier into conservation of different historical constructions, the reliability of those systems remain an important obstacle. For such cases, the computation modeling can unlock a new path toward a practical and convenient implementation of an efficient structural health monitoring system.

4 FINITE ELEMENT MODELING AND MODAL ANALYSIS

Based on the geometric survey, a sophisticated three-dimensional FEM of the superstructure was developed within ANSYS® in order to conduct modal analysis of the structure. As previously implied, only the main span of the bridge was considered for SHM application as common practices in vogue.

Keane Bridge is constructed with iron steel. But, the exact property of such 18th century iron was unknown. However, for convenience of analyzing historical structures, the British Constructional Steelwork Association Limited (BCSAL) published a handbook of historical structural steelwork, in which properties of European iron and steel sections including design, load and stress data are listed since the Mid-18th century. As the bridge was constructed in the same period, so it was assumed that the documented British standard

BS548 1934 (Bates 1990) was applicable for it. The required properties that were assumed and collected from the corresponding text are summarized in Table 1.

Table 1. Material properties assigned to the finite element model.

Properties	Value	Unit
Yield strength	22	tons/in^2
Strain	0.002	-
Poisson's ratio	0.3	-
Elasticity	22×10^6	psi
Density	0.2888	lb./in^3

Further, cross sectional properties of the members located in the unreachable regions were not possible to be obtained due to financial, technical and administrative limitations. In these circumstances, the sections were assumed from Bates (1990). The data used is provided in Table below:

Table 2. Members selected for FEM.

Member	Section type	Size inches	Name*
Stringer	I Beam	22 × 7	BSB 139
Floor beam	I Beam	24 × 7.5	BSB 140
Lateral, portal bracing and strut	I Beam	12 × 8	BSB 124
Sway bracing	Angle	2.25 × 2.25 × 0.5	-
Sway bracing strut	I Beam	7 × 4	BSB 111

* 'Name' represents names of the sections as appeared in Bates (1990).

All members of the bridge were modeled with Beam 188 – a structural 3 dimensional, 2 node beam element, where each node contains exactly 3 translational and 3 rotational DOFs (degree of freedoms) in X, Y and Z axis. The boundary conditions of the structure was defined as free rotations and constrained displacements. The model had total 375 elements with 173 nodes and 1002 DOFs – from which only translational DOFs were considered for possible sensor installation for SHM in the on-site test, as rotational DOFs are usually difficult to measure. Thus, the active DOFs for the bridge were reduced to 483 DOFs, which can be treated as the potential sensor positions for the next step of SHM.

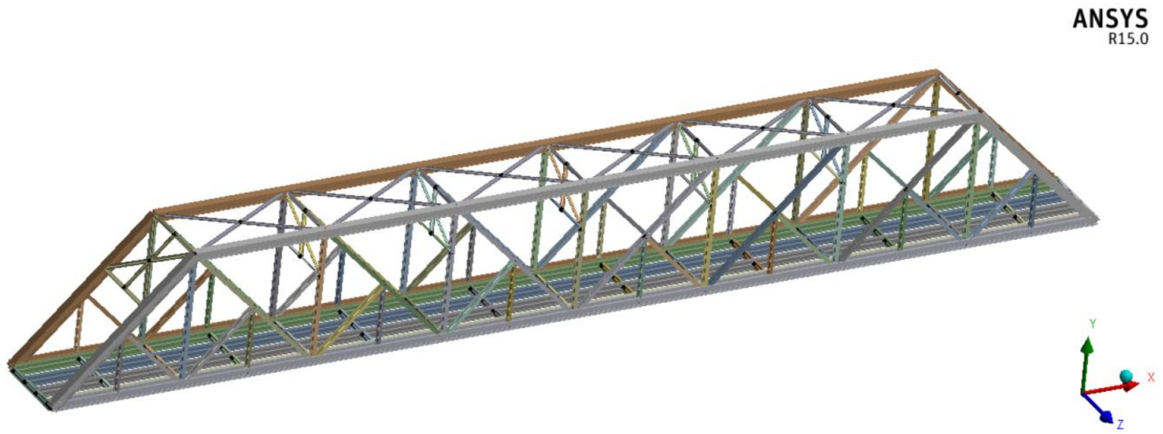
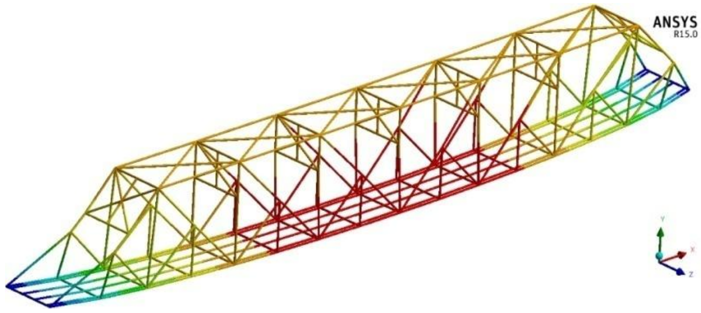
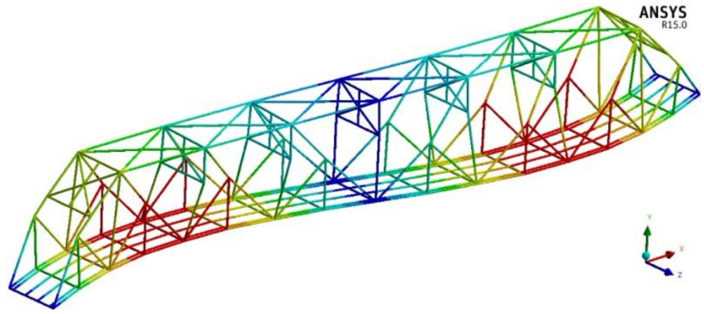


Figure 6. Isometric view of Kean Bridge finite element model.

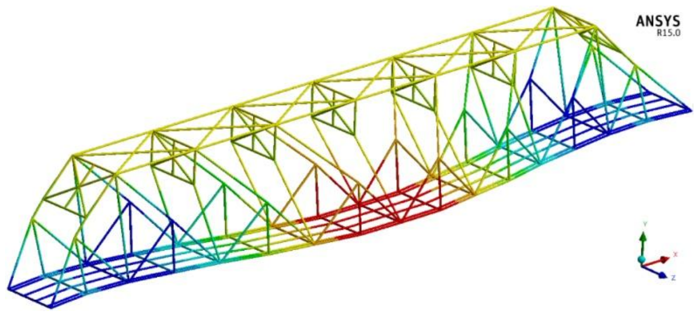
Afterward, to conduct the modal analysis, Subspace iteration method was adopted as the sparse matrix solver. The first 6 eigen mode shapes obtained from the modal analysis, were selected as the target modes for further experimental setup and are shown in Figure 5. To understand the dynamic response of the system, the mass participation factor ratio and the features of mode shapes are listed in Table 3. It can be observed that for selected mode shapes the bridge displays a narrow strap of low resonant frequencies with both symmetrical and anti-symmetrical bending of natural modes that are less coupled.



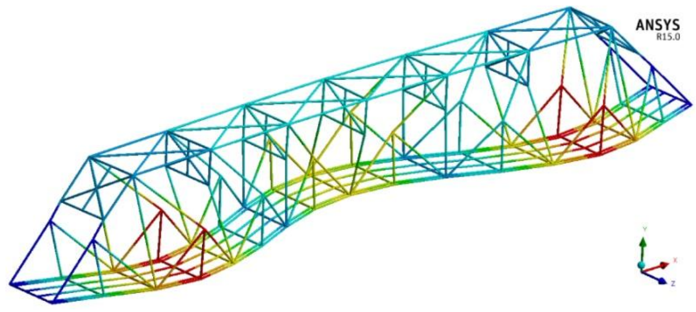
a) Mode 1: 0.92 Hz



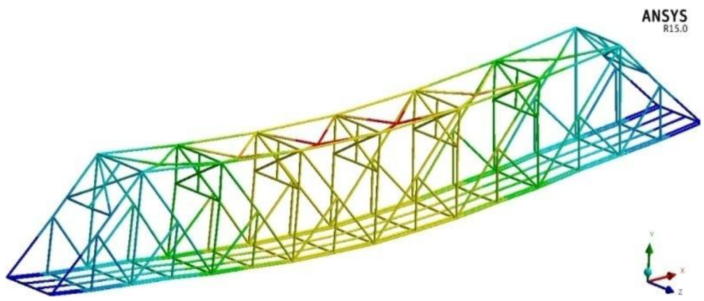
b) Mode 2: 2.11 Hz



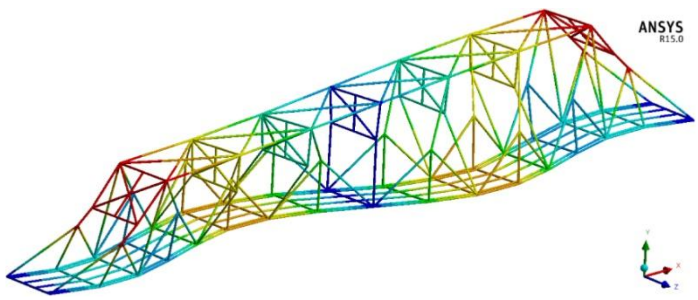
c) Mode 3: 2.69 Hz



d) Mode 4: 3.32 Hz



e) Mode 5: 3.61 Hz



f) Mode 6: 3.75 Hz

Figure 7. First six numerical eigen modes with natural frequencies of the bridge.

Table 3. Mass participation ratio and mode shape characteristics of obtained modes.

Mode no.	Participation ratio			Mode shape characteristics
	X-direction	Y-direction	Z-direction	
1	1.000	0.856	0.158	1st lateral bending of whole bridge about Z axis
2	0.700	0.531	0.339	2nd lateral bending of whole bridge about Z axis
3	0.065	0.369	0.501	1st torsional bending of whole bridge
4	0.069	0.704	0.417	1st lateral bending of girder and floor beam about Z axis
5	0.244	1.000	1.000	1st vertical bending of whole bridge about Y axis
6	0.419	0.512	0.401	2nd torsional bending of whole bridge

As shown in Table 3, the selected modes shows large participation ratio and can be defined as global modes. Mode 1 shows the greatest mass participation factor in X direction where Mode 5 having the greatest in Y and Z direction combined. This implies, this parameter setup will ensure to be practically adequate by allowing maximum vibration energy of the bridge.

5 CONCLUSIONS

Historical Kean Bridge has been a witness to the path of evolution of Sylhet city and Bangladesh. The bridge also represents the exquisite architecture and aesthetics of that time. To alleviate the concern about its conservation, assessment of its health has become crucial. In this paper, a full-scale 3D finite element model of the Kean Bridge is established and the modal analysis is carried out to obtain the dynamic parameters of the structure for SHM applications. The eigenvectors for selected modes show low resonant frequencies with large vibration energy of the structure. The mode shapes have demonstrated several symmetric and antisymmetric lateral, vertical and torsional deformation of the structure. Moreover, the natural frequencies and modal vectors obtained from the analysis can be used as the fundamental numerical data for further studies on sensor optimization, correlation of field test data and model updating for vibration based SHM technique in future.

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