International Journal of Research Radicals in Multidisciplinary Fields (IJRRMF), ISSN: 2960-043X
Volume 2, Issue 1, January-June, 2023, Available online at: www.researchradicals.com

Review: A Post-Tensioned Bridge Deck Slab's Construction

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ABSTRACT

The deck of a post-tensioned cast-in-place concrete slab bridge or any other design structure might be the focus of this paper's investigation towards optimizing embedded carbon emissions via the use of surrogate modeling. The ability to optimize structures in a logical and sequential manner is the primary value that this approach brings to the table. The strategy utilizes a sequential two-stage optimization process, the first stage being one of diversity, and the second stage being one of intensity of the search for optimal solutions. In the end, a heuristic optimization that is based on a Kriging metamodel is carried out in order to account for emissions as well as the distinguishing qualities of each design. If emissions were to be decreased, design advice would be to employ slendernesses as high as feasible, in the region of 1/30, which suggests a more substantial quantity of passive reinforcement. An optimized solution with fewer emissions than the sample that was evaluated. This increase in passive reinforcement is accounted for by a reduction in the measurement of active reinforcement as well as concrete. One further significant realization is that there is a correlation between lowering emissions and lowering costs. In addition, it has been shown beyond a reasonable doubt that reductions of more than 2% in the amount of emissions released into the air can be accomplished with an increase in costs.

Keywords: optimization, post-tensioned concrete, Bridge Deck Slab

INTRODUCTION

The present scenario regarding climate change is one in which the decrease of emissions is an important issue. The need of lowering one's carbon footprint has an effect on all aspects of human activity, especially those pertaining to building. In point of fact, building accounts for more than forty percent of the world's total energy consumption and more than thirty percent of the world's greenhouse gas emissions. According to some estimates, the manufacturing of structural concrete across the world accounts for more than 5% of carbon emissions. As a result, there has been a growing interest in optimizing environmental sustainability and implementing it into the building industry.

Optimum performance may be achieved in sustainable concrete building via a variety of approaches, such as choosing construction materials with designs that need the least amount of energy possible or improving structural systems. Utilizing new kinds of materials, such as infilled cementitious composites, which have the potential to dramatically cut down on carbon emissions is one alternative. Utilizing steel that has been previously recycled is still another option. Similarly, the optimization of concrete structures may minimize carbon emissions and the costs of construction. This sort of optimization has been accomplished on a variety of buildings, including building structures, bridges, and retaining walls, among other types of structures. According to the examples that were analyzed, it was discovered that costs and emissions are connected, seeing as how both drop when the amount of material that is utilized drops.

Our research group has published many papers on the topic of heuristic optimization of bridges, with emissions serving as the objective function in these analyses. a hybrid firefly-based algorithm was used to optimize a prefabricated trough girder bridge. The results showed that a decrease of only one euro may save as much as A post-tensioned box-section footbridge is optimized by Garcia-Segura et al., whose findings reveal that the emission decrease is reached with a greater number of important edges, more active reinforcing cables, and a lower concrete characteristic strength. Garcia-Segura and his team carried out an exercise to optimize a post-tensioned box-section bridge in terms of many criteria, including cost, emissions, and safety. analyzed two box-section bridges to demonstrate that the emissions produced during the demolition phase are much greater than those produced during the maintenance and repair phases of the bridge. It was also demonstrated that while carbon emissions are an important indication of environmental effect, in certain circumstances, it is inadequate, and other environmental impacts should be applied various metaheuristics to optimize cost and emissions in a single-span mixed concrete and steel footbridge. This was done in order to reduce the environmental impact of the footbridge. Martinez has just completed a study of research works that are associated with composite bridges.

However, one of the drawbacks of heuristic optimization of structures is that it requires a significant amount of processing power. It is common practice to employ approximations or metamodels. In order to resolve this issue, a simulation model has been replaced by a metamodel. In the field of structural design optimization, some of the most used metamodels are kriging, neural networks (NNs), and radial basis functions (RBFs). Kriging is one of the most promising surrogate models in structural engineering, however it is only used in a small number of projects to design actual buildings. This model gives an ideal interpolation that is based on the regression of the observed values and is weighted according to the values that are associated with the spatial covariance. Martinez—make use of kriging to solve the resilient optimum design of articulated structures, isolating the procedures of uncertainty assessment from the optimization process itself. This concept was recently extended to other sectors, such as the optimization of wind turbines and railroad slabs.

Kriging, in combination with other heuristic optimization methods, has been employed more often in recent years in bridge optimization, particularly in situations where the usage of finite elements requires a significant amount of computing effort to assist in the multi-objective optimization of the bridge subject to. This metamodel can be used to perform an economic and robust optimization on a prestressed box-section footbridge. The computation time was reduced by 99.06% using an optimization algorithm that was based on Kriging. The box-section bridges that were obtained using this algorithm differed from those obtained using heuristic optimization by simulated only by 2.54%. In several other recent publications, Kriging is used to optimize the use of lightweight slab bridges in emission calculations.

In order to accomplish numerous voided slab decks for post-tensioned road flyovers with a smaller carbon footprint, the purpose of this article is to propose a way to accomplish this goal. This is the first work to deal with optimization, and it uses a Kriging metamodel in order to optimize a post-tensioned concrete slab-bridge deck. The fact that this strategy enables us to solve complicated issues involving a big number of variables or situations in which the restrictions need a lengthy amount of processing time is the primary reason why it is important. The approach that was suggested has a generic nature, which means that it may be implemented in any other kind of structure to optimize a variety of objective functions. The implementation of a two-phase Kriging metamodel and the environmental optimization of lightened slab bridges are the two unique contributions that this study makes.

Description of the Lightened Slab Bridge Deck

It is typical practice to design a slab deck using prestressed concrete to function as a continuous hyperstatic beam. Bridges that have a major span of between 10 and 45 meters often make use of the slab solution. They are able to compete with precast girder bridges because to the structural benefits that they provide (higher torsional and bending stiffness, more durability and safety due to hyperstaticity), as well as the constructive advantages that they offer due to their capacity to adapt to tough decks using formwork concreting that is easier than in other typologies. Additional benefits could be added, such as the removal of roadway joints (which improves user comfort and lowers the danger of deck deterioration), more flexibility in the positioning of support parts, and improved aesthetic aspects. When walking or visiting the structure below the bridge, the aesthetics of the bridge are an important consideration, and this is facilitated by the fact that the formwork may be adapted to any length or curve.

During the course of this work, numerous voided slab decks for post-tensioned road flyovers with three spans of 24-34-28 meters and a total length of 86 meters will have their lengths optimized. It is solved by using an in-situ slab that has a profile that is straight and a constant depth. The deck has a width of 8.30 meters and is made up of two lanes that are 3.50 meters wide and barriers that are each m in height, in addition to a concrete pedestal. The properties as well as the dimensions of the cross-section are shown in Figure 2.

OBJECTIVE

1. The Study Post-Tensioned Bridge Deck Slab's Construction.
2. The Study Sustainable Concrete Structures Can Be Optimized Under Different Routes.

RESEARCH METHODOLOGY

A prestressing effect may be achieved in any concrete construction by the transmission of forces between the concrete and the prestressing tendons. Concrete is quite strong when it is compressed, but it is very weak when it is stretched. Because of the force that is communicated between the prestressed tendon and the concrete, the concrete will undergo a process known as pretensioning. Tension is placed on the tendons whenever they are tugged or strained. This compression in the concrete acts to counterbalance the stress in the tendons. Because of this, the tensile stresses that are induced by shear forces and bending moments that are caused by applied loading may be eliminated in concrete with the application of an external compressive force. The tendons may either be located on the outside of the body or on the inside. Additionally, it may refer to either bonded tendons or tendons that are not connected together. Again, they could be pre-tensioned or post-tensioned depending on the situation. Despite this, the outcome and underlying concepts have not changed. If the concrete is totally prestressed, also known as full prestressed concrete, then the longitudinal stress will always be in compression. However, if the concrete is just partly prestressed, then it will allow for some tension to develop under certain loading circumstances.

Components and methods for the process of prestressing As a result of the relentless progression of technologies in the realm of construction, there are now a wide variety of distinct systems that are capable of obtaining prestressing force in the parts of the structural framework. The Freyssinet, Magnel-Blaton, and Gifford-Udall systems are examples of well-known and widely used systems in India. In addition to the systems mentioned above, the nation has lately produced a large number of additional indigenous systems. The process known as pretensioning refers to the act of applying tension to reinforcing bars in a structure before the laying of concrete. In a similar manner, the technique known as post tensioning refers to the act of stressing and anchoring tendons after the process of casting concrete has been completed.

Bridge Loading

Perspectives on loading more generally In order to ensure that the construction of bridges is designed consistently throughout the whole of the nation, universal criteria have been established for the loads that must be taken into consideration during the planning process. The Indian Roads Congress (IRC) is responsible for developing detailed instructions that are written forth in standard specifications and standards. These rules and regulations are referred to collectively as Bridge Codes. The bridge codes currently have a total of eight parts, the first of which covers basic design considerations such as standards for primary data collecting, clearances, and foundations. Other sections cover topics such as loads and stresses. The next parts give direction for designing bridge super structures; they include cement concrete; brick, stone, and masonry in composite structures; steel road bridges are included in; and foundations, substructures, and bearings respectively in.

DATA ANALYSIS

Although the primary function of any bridge is to provide a safe passage for vehicles traveling over it, the most significant loading factor for almost all bridges is the bridge's own weight. This is because bridges are designed to bear their own weight. The environmental impacts, such as wind pressure, water pressure (if there is any), heat changes, and seismic effects, must be able to be securely resisted by the bridge in addition to the dead and traffic loads. The bridge must also be competent enough to do so. When designing a bridge, safety considerations need to be given to how the bridge will behave at each step of its construction in addition to how it will look when it is finished. In most cases, the study of a bridge is carried out in a manner that is distinct for the structure's transverse direction and longitudinal direction. Checks for things like moments and axial loads are performed in a direction perpendicular to the cross section, and then, in a separate study, the reaction in the longitudinal direction is examined while assuming that the cross section is rigid. Typically, the design in the transverse direction is dominated either by the moment that is caused by dead loads or the moment that is caused by uniform live loads. The moment that is often created by the concentrated wheel loads is spread out across a significant distance along the length of the bridge. Because of this, there is less of a necessity to take into consideration these loads throughout the segment. When calculating the moments caused by concentrated loads, it is often necessary to assume that the dispersion angle is 45 degrees.

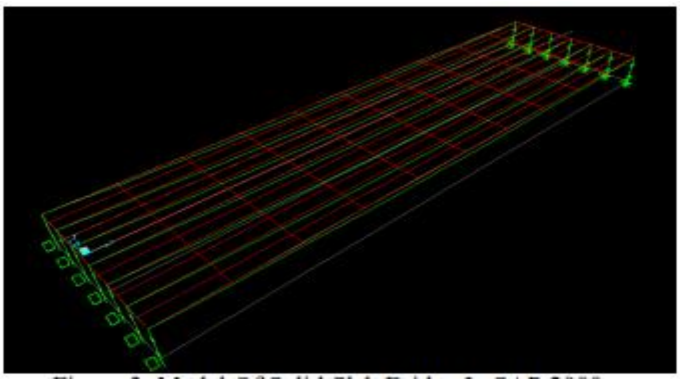

Figure 1: Model Of Solid Slab Bridge In SAP

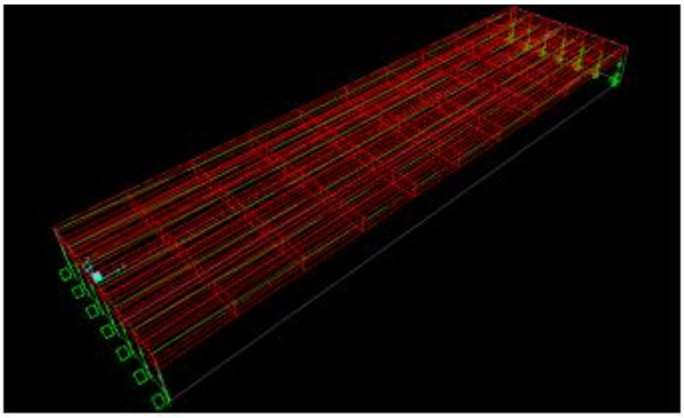

Figure 2: Model Of Voided Slab Bridge In SAP

After that, the findings are analyzed in order to derive some useful lessons from the bridge that was optimized for emissions (or BOE for short), which may be used to the process of designing this structure. Slenderness is at the limit allowed by the Dirección General de, which recommends slenderness between 1/22 and 1/30 for post-tensioned road flyovers. The BOE depth/span ratio is 1/30.91. The recommended for slabs with three or more spans and large overhangs is 1/28, if we are to follow the ideas made by. In all instances, the BOE makes an effort to lessen the depth of the deck. When we compare this depth/span ratio with the statistical data from, we observe that the slenderness is larger than the 75% percentile, which is 1/26.39. In addition, just one of the examples that were evaluated displayed a slenderness that was greater than 1/30, which suggests that this optimum displays enormous slendernesses.

On the other hand, the BOE estimates that there will be 0.56 m3 of concrete for every square meter of deck space. This result is within the lower range of the guidelines, which include values between 0.55 and Additionally, it falls within the 25th percentile of the range. The outcome of the test demonstrates that the BOE intends to minimize the amount of concrete that is measured. Although it is inside the prescribed range of 10 and 25 kg/m2, the quantity of active prestressing for the BOE, which is 16.48 kg/m2 of the slab, is less than 25% of the total. This also suggests that there is a general trend toward using a lesser degree of active pretensioning.

The passive reinforcement recommended by the BOE comes in at 136.85 kg/m3 of concrete, which is higher than the guidelines, which recommend amounts between The reality, on the other hand, shows that the median is 100.87, which suggests that the are lower than what is really carried out on real-life bridges. In addition to this, the passive reinforcement of the most effective bridge is lower than the highest value found in the sample, which was 187.08 kg/m3. If we look at the BOE ratio of the deck, which is 77.00 kg/m2, we see that the value is still rather high. It is more than the 75% percentile of the sample, but it does not approach the highest value of 92.91 kg/m2. Based on these numbers, one may draw the conclusion that decks with lower emissions favor greater passive reinforcing to decrease the amount of concrete and active prestressing.

The next step is to contrast the BOE with the forecast. This necessitates the knowledge of whether or not the optimization of the carbon footprint incorporates adjustments affecting the linear In point of fact, in that job, the needed active prestressing, the deck depth, and the concrete measurement were all able to be anticipated by only knowing the main span in addition to the internal and exterior lightening. It is anticipated that the amount of active prestressing required for the bridge with reduced emissions would be 21.22 kg/m2. In spite of this, the actual need was just 16.48 kg/m2, which is much less. Because of this, the BOE employs a far lower level of active pretensioning than is normally utilized. The advice from the design team would be to cut this number down as much as is humanly practicable. In a similar vein, the depth would be calculated to be 1.13 meters, however in BOE, it is 1.10 meters, which is essentially the same. The amount of concrete that is anticipated to be present is 0.52 m3/m2, which is comparable to the BOE value of 0.56 m3/m2. These suggestions are in line with those that were reached by previously using heuristic optimization approaches; however, in that instance, the objective function cost was taken into consideration.

Checking the relationship between the depth-to-main-span ratio and the measurement of the concrete is an additional important topic to look into. Figure 7 demonstrates that it is beneficial to have a high slenderness, which is larger than 1/28, and to keep the volume of the concrete as low as feasible, which is less than 0.60 m3/m2. The measurement of concrete that was achieved is in agreement with the work of, who, for the purpose of the economic optimization of this kind of bridge, offers magnitudes of around 0.50 m3/m2. The similar thing takes place with the depth to span ratio, which hovers around 1:25 for economic decks with wider spans.

CONCLUSION

This study analyzes and evaluates the best possible design for a pedestrian deck made of post-tensioned concrete box girders. A software that examines the structure is having its functionality expanded so that it may assess and optimize the whole cost. It has been shown that the SAMO2 algorithm, which combines SA with a mutation operator, is an effective method for the optimal design of economic solutions. The calibrated approach includes a random fluctuation of up to fifty percent of the variables, the starting temperature determined by Medina's method, Markov chains with five thousand iterations, a cooling coefficient of eighty percent, and a stop criteria of three Markov chains that do not show progress. The local optima that were identified by using SAMO2 are extreme values that are compatible with a three-parameter Weibull distribution, with g being an estimate of the global optimum that this approach may possibly attain. When compared to the theoretical minimum value, the best value that SAMO2 could find was just 0.34 percentage points off. The findings are highly positive, and they imply that this technique might readily be modified to address the optimization needs of additional issues. The use of high-strength concrete, on the other hand, allows for a shallower pour and a smaller volume of concrete overall, which, in turn, leads to a reduction in the overall cost.

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