APPLICATION OF A SOFTWARE PROGRAMME LANGUAGE CALLED PYTHON IN DETERMINING THE LOADS AND LOAD DISTRIBUTION IN THE DECKS OF A LONG SPAN REINFORCED BRIDGE DECK

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Abstract

This research was to create software that can analyze, design and determine the cost of a beam/ deck for a simple supported bridge, the name of the software is Ivy. The method employed for the analysis is a grillage method, using finite element (beam element) and comparing the results with a manual approach (moment distribution and influence line). A 15m span was considered with a width of 7.5m, using a grillage distance of 1.5m, a knife edge load of 120KN and a uniformly distributed load of 30KN/m. The BS5400 and BS 8110 were used for the analysis and design. The result shows that values for the maximum bending moment locating the knife edge at 3m from the support is Mmax = 412KNm (manual approach), Mmax= 506.25KNm (Ivy) to give a percentage difference of 18.6%, at 6m, Mmax= 653KNm (manual approach), and Mmax= 566.25KNm with a percentage difference of -15.3%, at mid span 7.5m, it is Mmax= 789KNm (manual approach), Mmax= 768.75KNm(ivy) indicating a percentage difference of -2.63%. Similarly, the shear force at support locating the knife edge load at 3m is Vmax= 24.81KN (manual approach), and Vmax= 33.75KN (ivy) to give a percentage difference of 26.4%, at 6m, Vmax = 57.58KN (manual approach), and Vmax= 67.50KN (ivy) to give a percentage difference of 14.6% while at mid span 7.5m,Vmax = 38.98KN (manual approach), and Vmax= 67.50KN (ivy) to give a percentage difference of 42.2%. The main reinforcement area of steel locating the knife edge load at 3m is As = 5419mm^2 (manual approach), and As = 5271.72mm^2(ivy) with a percentage difference of -2.7%; at 6m, As = 6145mm^2(manual approach), and As = 5910.52mm^2(ivy) with a percentage difference of -3.9%, while at mid span 7.5m, As = 8617mm^2(manual approach), and As = 8088.6mm^2(ivy), giving a percentage difference of -6.5%

Keywords: *Simply supported long span bridge/deck, Python, Finite element (beam element)*

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1. BACKGROUND INFORMATION

Bridge engineering has been one of the most crucial parts of civil engineering design projects. Engineers are faced with daunting task in designing and erecting this structure. One of the major problems of bridge design are its loads and load distribution. There are lots of methods used in the analysis and design of a bridge, but this research is based on the development of finite element model of a long span bridge decks as a grillage using a software programme language called Python. A long span bridge can be defined as a bridge with great distances which are held up by at least two support set to the ground. Bridges ranges in length from a few metres to kilometers.

"Python is a dynamic object-oriented programming language that can be used for many kind of software development. It offers strong support for integration with other languages and tools comes with extensive standard libraries and can be learned in a few days. Many python programmers report substantial productivity gains and feel the language encourage the development of higher quality, more maintainable code" [17].

The main aim of this paper is to present the results of the development of a software for the analysis and design of a long span reinforced concrete highway bridge based on BS5400(1990) and BS8110(1997), and its application to determine the loads and load distribution in such structures.

2. OBJECTIVES

The specific objectives are

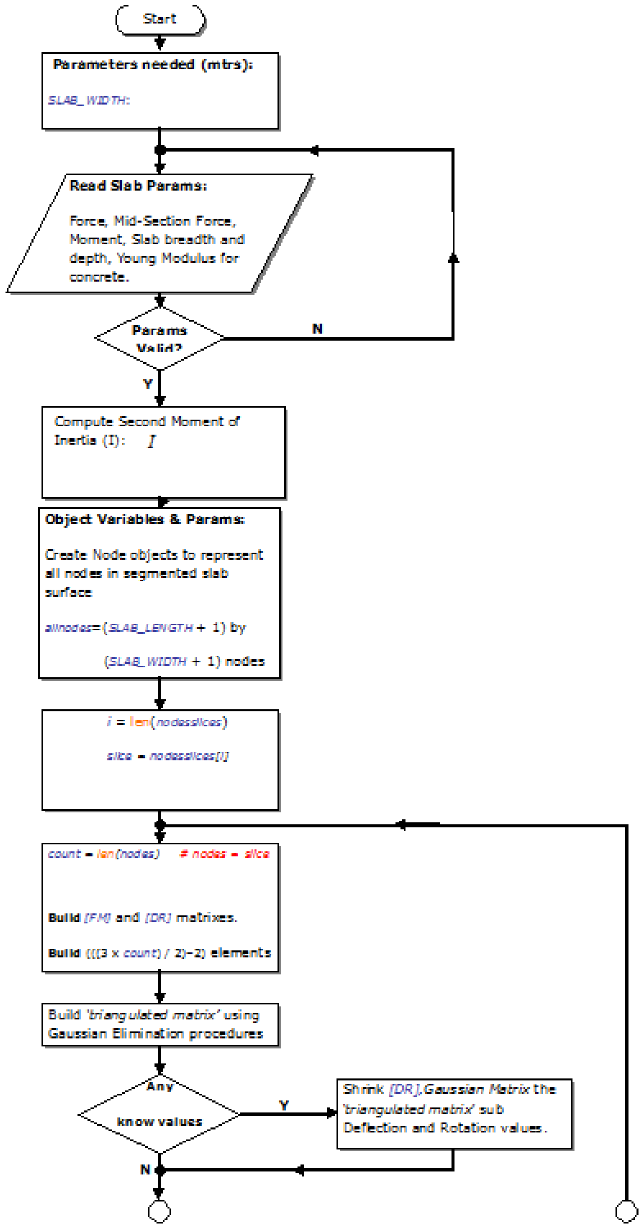
- to model the deck/ beam system using finite element
- to develop a software for the design of the members.
- to test the model and design and compare it with manual design.

3. METHODS

An algorithm for the development of a mesh was created using the finite element method for the bridge element .The computer analysis was carried out using the input data which describe fully the idealized structure and its loading, and produces output consisting of tabulated nodal displacements and element stresses. Figure 1 summaries the basic requirement of the computer program necessary for the complete solution of a program by finite element method.

3.1 Analysis and Design of a Bridge Deck Algorithm and Description

The detailed of the design and analysis procedures adopted for the study are illustrated in Figures 1 and 2



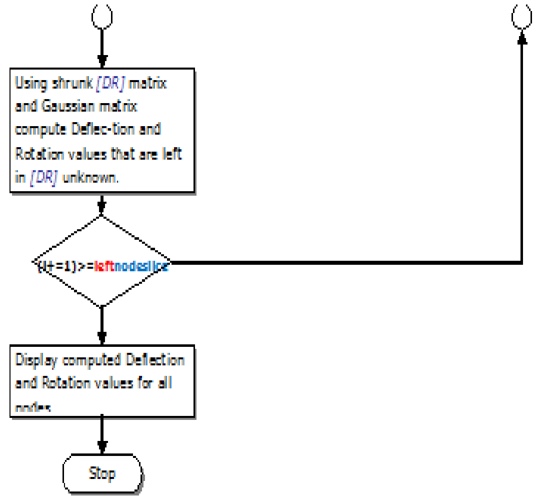


Fig 1: Detailed algorithm for the analysis of bridge deck.

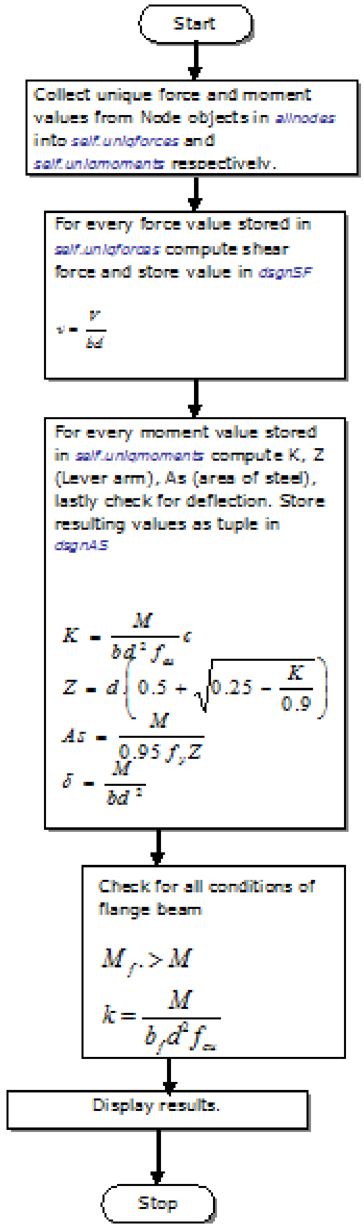


Fig 2: Detailed algorithm for the design of the bridge deck

The structural analysis and design of the bridge consist of a reinforced concrete deck of 15 m long simply supported, 7.5 m wide and a meter deep. The layout of grillage consists of 5 longitudinal members, 10 transverse members and 66 numbers of nodes using a grillage length of 1.5m.

The loading consideration adopted is illustrated in Figure 3.

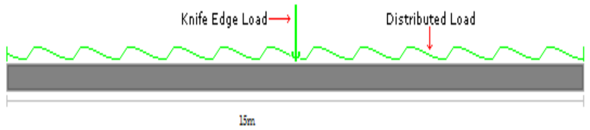


Fig 3: Adopted Loading Consideration

A uniformly distributed load of 30 kN/m2 was based on the British Standard No 5400,part 2: 1990 (for lengths up to 30m). A knife edge load of 120 kN was placed at critical points perpendicular to the notional lane. (HA Loading). The element of the deck consisted of a breadth of 1500 mm, depth of 900 mm, slab depth of 100 mm and a web thickness of 300 mm. An overall height of a meter was employed in the analysis and design of the bridge deck. This is illustrated in Figure 4.

The design criteria adopted included the use of BS 5400[3] and BS 8110[4], all calculations were executed using the Limit State method. The design criteria include the concrete strength of 25 N/mm^2 and young modulus of concrete as 25 kN/mm^2. The high yield value of 460 N/mm^2 based on BS 4449[2]. The reinforcement is considered to be the same order of magnitude in the longitudinal and transverse direction.

Fig 4: The Element of the Deck

3.2 Analysis and Design of a Bridge Deck Using Manual Approach.

The structural analysis and design of the bridge consisted of 7 numbers of precast reinforced concrete beams with dimensions 300 x 900 at 1500 mm center to center. The deck consisted of precast slabs with dimensions 100 mm over the precast beams to serve as formwork for the 140 mm deep cast in situ concrete slab on top. The load and forces considered include dead loads and imposed live loads of 30 kN/m^2 which were employed in the analysis. The design criteria and material considered were the same as the one employed for bridge Beam/Deck software.

3.3 Programming for the Software and Testing the Developed Software

The Programming for the software adopted was the Python Programme. In its simplest form, a Python programme is just a text file containing Python statements. For example, the following file, named script1.py, is one of the simplest Python scripts, but it passes for an official Python program:

```
print 'hello world'
print 2 ** 100
```

The file contains two python print statement, which simply print a string (the text in quote) and a numeric expression result (2 to the power 100) to he output stream.

A file statement of any text editor can be created but the python program files are given names that end in "*.py*". After the statements are typed into a test file in one way or another, python will execute the file; simply, this means it runs all the statements in the file from top to bottom, one after another. If the program goes well, the result of the two print statement shows up in the computer-by default, usually on the same window the program is run. Consider the following:

```
hello world
1267650600228229401496703205376
```

For example, here is how this script ran from a DOS command line on a Window's laptop, making sure it did not have any silly typos:

```
D:\temp>python script1.py
hello world
1267650600228229401496703205376
```

A python script has just been run which printed a string and a number which would capture the basics of the program execution.

The results obtained for the analyses and design of a bridge deck using the ivy bridge was compared with ones undertaken manually. HA loading was considered for the testing.

4. RESULTS AND DISCUSSION

This section gives the complete summary of all the findings from the study. The results are discussed with the comparison of established results obtained for the test bridge deck analysis and design. Critical points are taken into consideration in the comparison.

The data for the structure is a uniformly distributed load of 30 kN/m^2 and a live edge load of 120 kN/m^2 over a width of 7.5 m, length of 15 m and a meter deep with a grillage of 1.5m length as illustrated in fig 6.

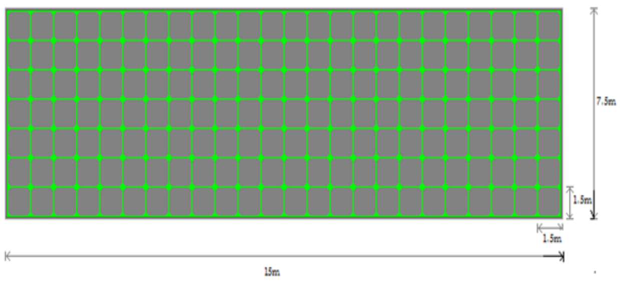


Fig 6: The Data for the Structure

The percentage differences of each value are obtained by the difference between the manual results and CADBBDD result dividing it by CADBBDD result and multiplying by a 100.

The summary of results for the bending moments for the interior beam is illustrated in Table 1.

Table 1: Maximum Bending Moment Values

Location of Knife edge load (m)	M_{max}(Manual Results) (KNm)	M_{max}(CADBBDD) (KNm)	Percentage Difference (%)
3	412	405	-1.7
6	653	607.5	-7.4
7.5	789	712.5	-10.7

The table shows the maximum bending moment's value of a beam, from the deck in questions, values obtained using the manual design are much higher than that of CADBBDD. Similarly, the summary of results for the shear force values for the beam is given in Table 2.

Tables 2: Shear force values for the beam at the support

Location of knife edge load (m)	Forces (manual) (KN)	Forces(CADBBDD) (KN)	Percentage difference (%)
3	24.81	33.75	26.4
6	57.58	67.50	14.6
7.5	38.98	67.50	42.2

From the results in the table, the shear force values obtained using the manual method is much lower than that of ivy, thereby giving an increase in the percentage difference. The application of the knife edge load gives rise to the values at each of the location points and, of course, a large difference between the values of the two different methods. A percentage increase was established in the shear value computation.

The ultimate bending moment for both loadings are taken into consideration, the areas of both reinforcements are illustrated in Table 3. A percentage decrease was obtained from the results obtained

Table 3: Summary of main reinforcement of steel

location	Manual Method As (mm^2)	CADBBDD As(mm^2)	Percentage difference (%)
3	5419	5092.92	-4.7
6	6145	5910.52	-3.9
7.5	8617	8088.6	-6.5

The format of the developed software is illustrated in Figure 7. This software for the analysis and design of a reinforced concrete highway bridge deck/beam was developed based on BS 5400[3] and BS 8110[4]. The grillage method of analysis was adopted and the software was written in "python" programming language as explained earlier.

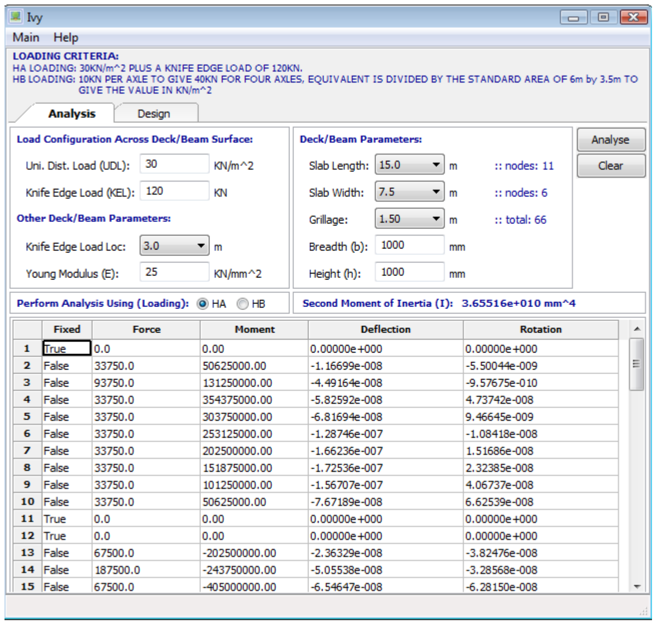


Fig 7: The Software Format

5. CONCLUSION

The software was tested for the analysis and design of a typical bridge deck/ beam and results were compared with those from manual method of analysis and design. The results indicate that the developed software provides

i) An easier means of analysis compared to the manual approach which is tedious;
ii) A cheaper cost of materials;
iii) A user-friendly method of analysis, and
iv) An easy-to-learn language.

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