Conceptual Automation For 3D Modeling Of Segmental Bridge Superstructure For FEM Software

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Abstract- *Innovations and economical design solutions for segmental bridge superstructure lead to the concept of structures having varying cross section along the main primary direction; and hence ultimately lead to the demand of generation of Three Dimensioned models (3D models) for analysis in different finite element method (FEM) based software. As manual 3D model preparation right from scratch in FEM based software is becoming more complicated and time consuming for varying cross-sectioned members, here an attempt is made to accommodate procedure of making this task somewhat easy by doing not only pure programming in AutoLISP, but by doing programming in different software (as per their usefulness) and then interlinking the same. The objective is to spread knowledge of 3D modeling atomization for segmental bridge using AutoLISP and how different software could be used smartly as per specific programming stage requirements. Efforts made in this study may enhance understanding of how to make the 3D model making process somewhat easy by providing atomization with the use of the programming languages (especially AutoLISP) and by interlinking of different software's for segmental bridge superstructures. Efforts made in this study may also enhance understanding of development of package for final product using interlinking of different software tools according to usefulness of different software's.*

Keywords- Three Dimensioned model, varying cross section, segmental bridge superstructure, SAP nonlinear.

I. INTRODUCTION

The very first step in analysis of any structures in FEM based software, like SAP nonlinear, is generation of Three-Dimensioned (3D) model. And for segmental bridge superstructures having varying cross section along the main primary direction, the manual preparation of 3D model right from scratch is becoming more complicated and time consuming.

Hence, here an attempt is made to accommodate the procedure of making this 3D model generation task easy by using different software like M.S. Excel, Auto-LISP, SAP nonlinear, etc. (as per their usefulness) and then interlinking the same.

In following pages this conceptual modeling using Auto-LISP for segmental superstructures having varying cross-sections for three dimensioned analysis in SAP nonlinear software are discussed.

II. MODEL GENERATION

2.1 Generation of Three Dimensional (3D) Model Geometry in AutoLISP:-

2.1.1 Preliminary Dimensioning & Geometry:

Very first step in analysis of segmental bridge superstructure is assumption of first trial geometry to calculate sectional properties and self weights of different segments between varying cross-sections.

To fulfill the objective of this paper and to understand this conceptual modeling using Auto-LISP, a published problem of the varying depth bridge superstructure having 80.50 meter span is selected [1] as shown in figure 1(c). Elevation with segment and section numbers, Preliminary cross-section dimension at support, near mid span and longitudinal geometry are as shown in figure 1(a), figure 1(b) and figure 1(c) respectively; for which atomized conceptual model geometry process is explained and to be set-out. The process is carried out for one of the half-section (i.e. for 80.50/2 = 40.25 meter span) as per symmetry at middle point. The following are the parameters used:

(a) Center to center Span:------------------------------ 80.50 m
(b) Depth at support & mid:--------------- 4.30 m & 1.60 m
(c) Total width of member (transverse):------------ 14.40 m
(d) Nos. of webs for carriage way:---------------------- 3 Nos
(e) Cantilever length on outer side:-------------------- 1.975m
(f) Cantilever length on inner side:-------------------- 1.275m
(g) Haunch size: ------------------------------- 0.60 m x 0.50 m
(h) Length of first, middle, end segment- 4.96m, 3.14m, 0.75 m

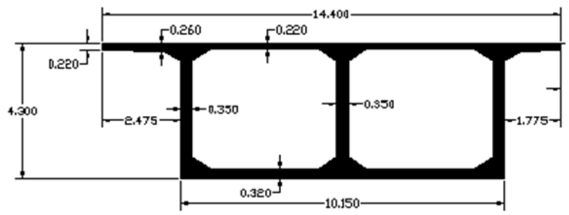


Figure 1(a) Cross-Sectional Dimensions at support

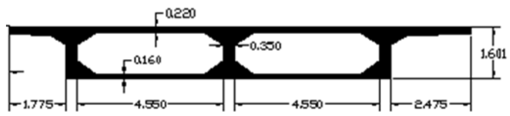


Figure 1(b) Cross-Sectional Dimensions at mid span

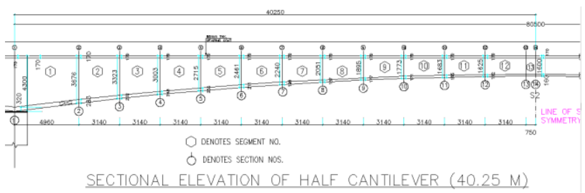


Figure 1(c) Elevation of Half Cantilever.

2.1.2 Sectional Properties at Different Sections:

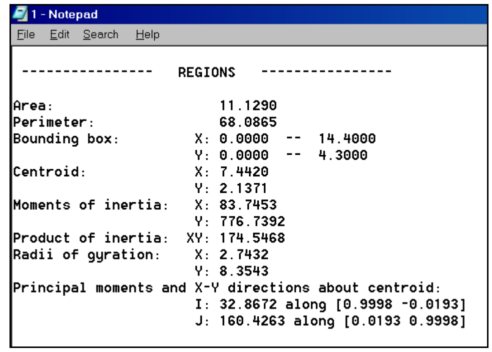
Having finalized the preliminary dimensions and sections at support as well as at mid span (as moving towards the mid span the depth of the girder as well as the thickness of lower flange reduces parabolically), the sectional properties at all different sections of segments would be required for analysis and design process. This task can be atomized & performed easily by using an AUTOLISP program hgeo.lsp[1], which not only draws different sections length-wise but also give the sectional properties of the different sections as output files (.mpr files) as shown in figure 2 .

Input:-

hgeo.lsp program requires two input files hpoints11.txt & horigine.txt containing "co-ordinates of different points to generate geometry" and "details of points of various boundary selection windows" for every section respectively. This x, y and z coordinates of different points for geometry generation can be easily prepared b using basic formulae in M.S. Excel.

Output:-

Outputs files (.mpr files) are generated in a number equal to number of sections, which gives the sectional properties of different sections. Figure 2 shows the sample output file of atomized AutoLISP program hgeo.lsp containing sectional properties of different sections [1].


```
1 - Notepad
File  Edit  Search  Help

----------------   REGIONS   ----------------

Area:                   11.1290
Perimeter:              68.0865
Bounding box:        X: 0.0000  --  14.4000
                     Y: 0.0000  --  4.3000
Centroid:            X: 7.4420
                     Y: 2.1371
Moments of inertia:  X: 83.7453
                     Y: 776.7392
Product of inertia: XY: 174.5468
Radii of gyration:   X: 2.7432
                     Y: 8.3543
Principal moments and X-Y directions about centroid:
                     I: 32.8672 along [0.9998 -0.0193]
                     J: 160.4263 along [0.0193 0.9998]
```

Figure 2 – Sample output file of hgeo.lsp.

2.2 3D Model Generation for SAP Non-linear software:

For carrying out 3D analysis in SAP Non-linear software, the entities of structure or members, in the form of connected shell elements would be required. This task can be performed easily by using another Auto-LISP program hsapshell.lsp[1] by using following as inputs.

Input:- hsapshell.lsp program requires one input file hsapshell.txt containing "co-ordinates of different mid points of shell elements required generating model geometry in form of shell elements.

Output:

Figure-3 shows the model generated in .dxf format [output of hsapshell.lsp]. in the form of connected shell elements to import in SAP non-linear software for 3D analysis[1].

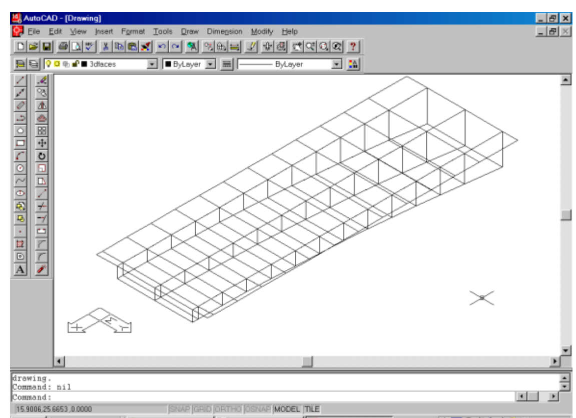


Figure 3 – View of 3-D Model generated by hsapshell.lsp

Once the Three-Dimensioned (3D) model generated by running hsapshell.lsp program is imported in SAP non-linear platform as shell elements, different analysis can be carried out by defining shell thickness, loads, etc.

Figure 4 shows a view of 3D model after defining shell thicknesses and loads.

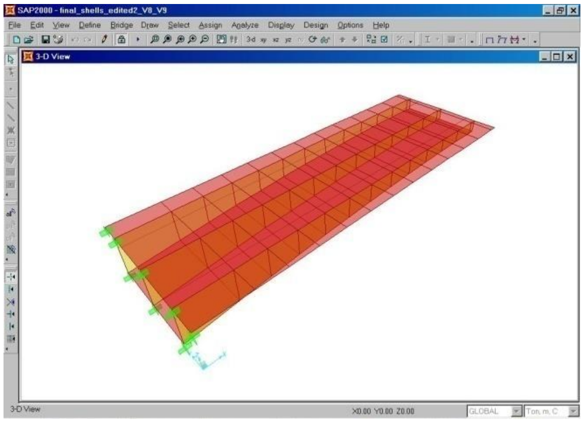


Figure 4 – View of a 3D model in SAP after defining shell thickness.

Figure 5 shows the view of model of whole fixed span for SIDL analysis. SIDL will be applied after completion of two half cantilevers and after they made continuous.

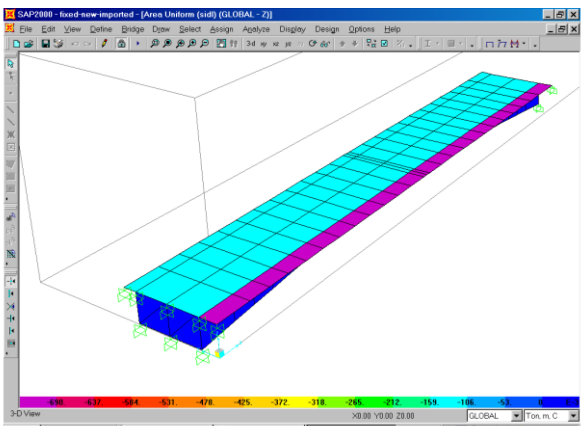


Figure 5 – View of SIDL analysis on 3D model imported in SAP Non-linear platform

III. CONCLUSION

The objective of this paper was to spread knowledge of atomization using AutoLISP and how different software could be used smartly as per specific programming stage requirements. Efforts made was to enhance understanding of how to make the 3D model making process somewhat easy by providing atomization with the use of the programming languages (especially AutoLISP) and by interlinking of results of different software.

Important features of this paper are as follows:

- Main emphasis is given to develop an atomized process by interlining of programs used (which is achieved by using output of one program as an input for the next program module to be used), and to generated the outputs as many times as required so that model can be easily revised as per minor changes if anywhere required.
- Most economical and safe sections can be achieved by taking numbers of trials with minimum of time once such kind of atomized process is developed. This type of atomization is most useful to designer personal or designing corporate.

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REFERENCES

[1] Hardik R. Trivedi, "Segmental Bridge Design of Prestressed Box Superstructure for Cantilever Construction" at International Journal of Bridge Engineering (IJBE), Vol. 3, No. 1, (2014), pp. 01-34., 2014.