Modelling of a bridge with irregular geometry

Programmatic approach for FEA models based on MATLAB and STAAD.Pro

Project by:
Mihhail samusev (VIA)

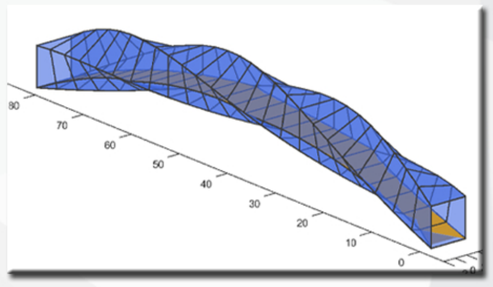
Supervised by:
Torben Brøchner (VIA)

VIA University College
Januar 2016

Introduction

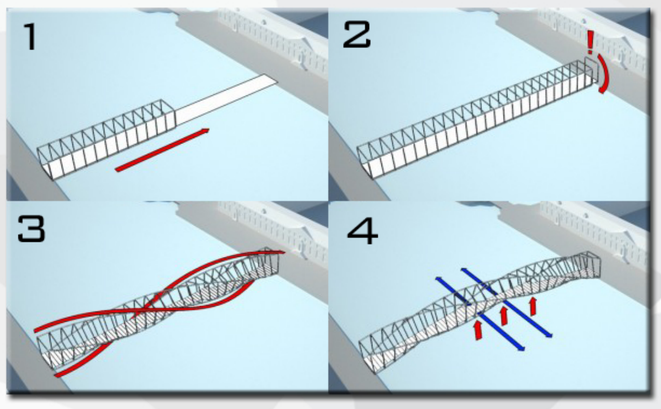
HELIXXX Bridge is a proposal for amsterdam iconic bridge competition 2012 suggested by Eugenio Aglietti.

Modelling of the bridge in STAAD.Pro is challenging due to its irregular geometry.



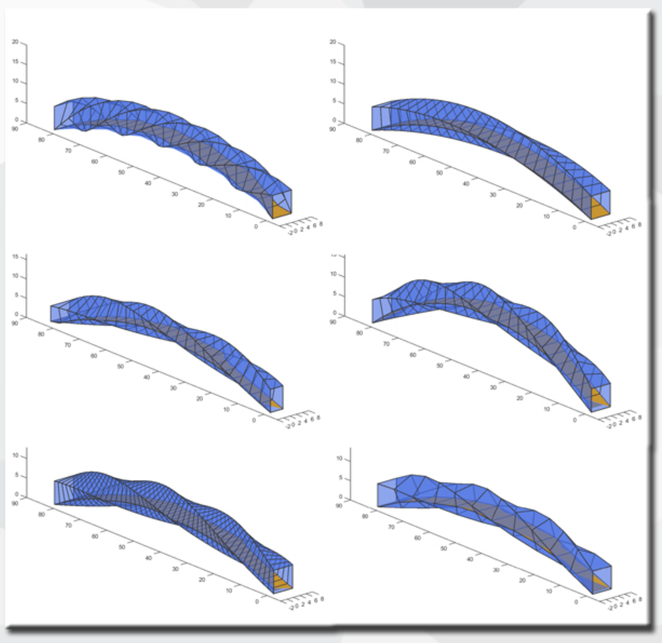
Instead of manual modelling, the work is done using parameter/algorithm based workflow through MATLAB and ASCII that in the end is transfered to STAAD Script format.

Method



Modelling sequence:
Frame forming
Frame translation
Frame rotation
Body bend up
Pathway cut through

Key principles:
Affine transformations
Node index progression data
Nearest Neighbour algorithm for pathway

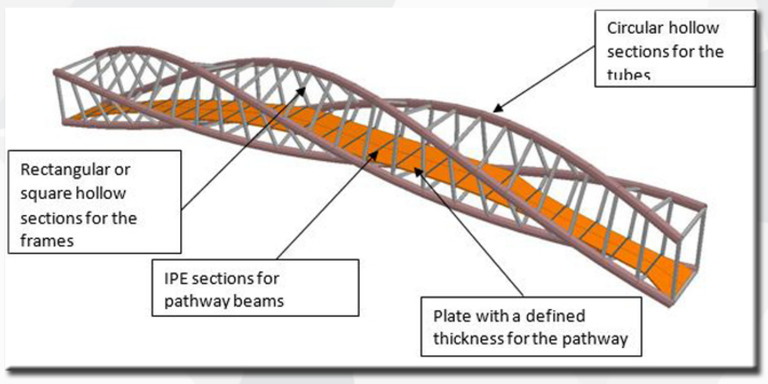


Geometry modification based on combination of 7 independent parameters:

Lenght
Amount of frames
Frame width
Frame height
Body rotation
Bend up (body)
Bend up (pathway)

Translation of MATLAB raw topology data to STAAD Script using standard definition commands + ASCII.

JOINT COORDINATES				MEMBER INCIDENCES			ELEMENT INCIDENCES SHELL				
1	0	0	0;	1	1	2;	547	1	162	163	351;
2	0	6	0;	2	2	3;	548	162	167	168	163;
3	6	6	0;	3	3	4;	549	167	172	173	168;
4	6	0	0;	4	4	351;	550	172	177	178	173;

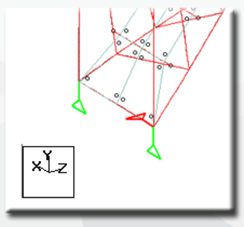


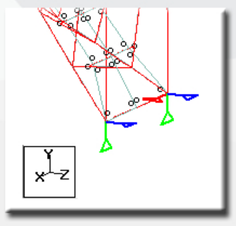
Standard steel members applied to necessary members whos indexing is known from geometry generation phase.

Design data is translated to STAAD Script by means of ASCII.

```
DEFINE MATERIAL START
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005
END DEFINE MATERIAL
```

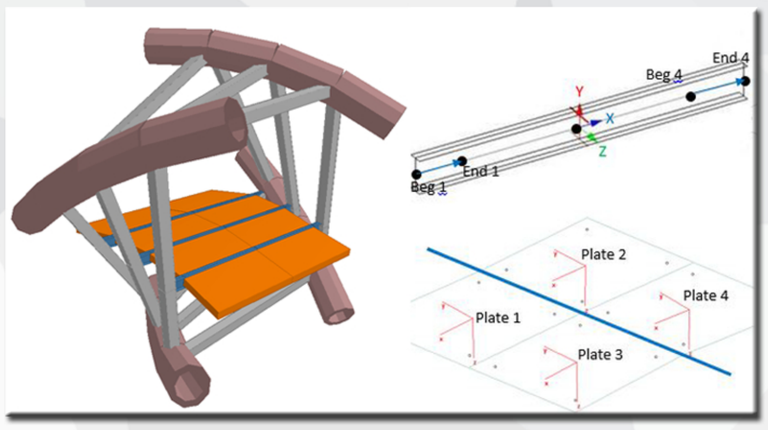
```
MEMBER PROPERTY EUROPEAN
1 TO 238 TABLE ST 300x12.5SHS
239 TO 394 TABLE ST PIPE OD 1 ID 0.7
395 TO 546 TABLE ST IPEA300
ELEMENT PROPERTY
547 TO 624 THICKNESS 0.2
CONSTANTS
MATERIAL STEEL MEMB 1 TO 624
```





Supports are modelled to allow movement in X and Z directions.

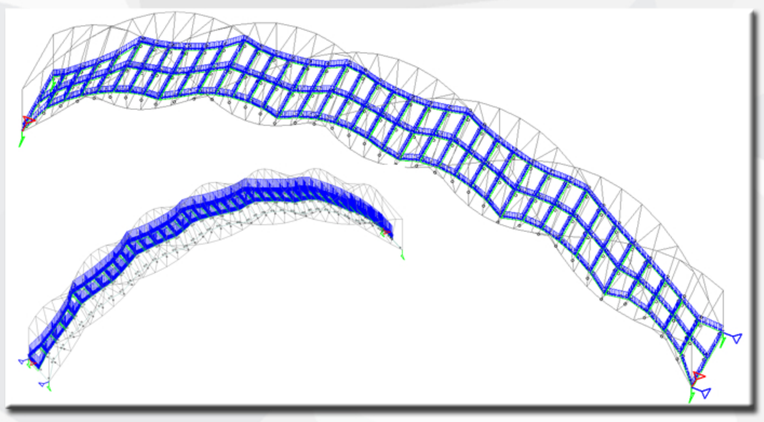
```
SUPPORTS
1 FIXED BUT MX MY MZ
4 FIXED BUT FX MX MY MZ
159 FIXED BUT FZ MX MY MZ
158 FIXED BUT FX FZ MX MY MZ
```




```
MEMBER RELEASE
395  399  403  407  411 START MZ
415  419  423  427  431 START MZ
435  439  443  447  451 START MZ
455  459  463  467  471 START MZ
475  479  483  487  491 START MZ
495  499  503  507  511 START MZ
515  519  523  527  531 START MZ
535  539  543 START MZ
398  402  406  410  414 END MZ
418  422  426  430  434 END MZ
438  442  446  450  454 END MZ
458  462  466  470  474 END MZ
478  482  486  490  494 END MZ
498  502  506  510  514 END MZ
518  522  526  530  534 END MZ
538  542  546 END MZ
```

```
ELEMENT RELEASE
547 TO 624 J1 MY MX
547 TO 624 J2 MY MX
547 TO 624 J3 MY MX
547 TO 624 J4 MY MX
```

Pathway beams are released to model simply supported behaviour. Pathway plates are released to transfer only vertical forces to the beams.



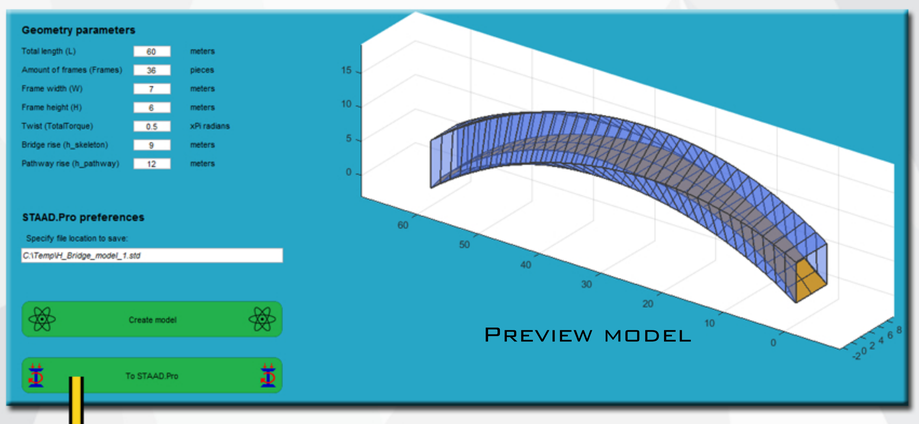
```
LOAD 1 LOADTYPE Dead  TITLE G member weight
SELFWEIGHT Y -1 LIST ALL

LOAD 2 LOADTYPE Dead  TITLE G cover
MEMBER LOAD
1 TO 238 UNI GY -1

LOAD 3 LOADTYPE Live  TITLE Q crowd full
ELEMENT LOAD
547 TO 624 PR GY -5
547 TO 624 PR LX 0.5

LOAD 4 LOADTYPE Live  TITLE Q crowd eccentric
ELEMENT LOAD
547 TO 585 PR GY -5
547 TO 585 PR LX 0.5

LOAD 5 LOADTYPE Accidental  TITLE A vehicle
ELEMENT LOAD
566  605 PR GY -1000 -0.1   -0.1    0.1    0.1
565  604 PR GY -2000 -0.1   -0.1    0.1    0.1
566  605 PR GZ -24 0  0
565  604 PR GZ -48 0  0
```

Bridge loads and lombinations are applied according to Eurocodes 1 and 3.

```
PERFORM ANALYSIS PRINT STATICS CHECK
FINISH
```

Results

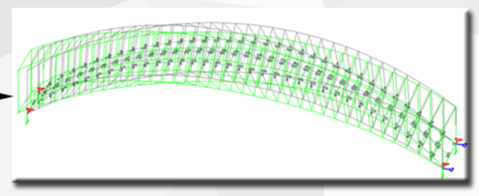
UI allowing for interactive geometrical adjustments of the structure with direct upload to STAAD.Pro with all design data (properties, supports, releases, loads) necessary to start



Preview model

Upload to STAAD

Start analysis



Discussion

Fine modelling method for STAAD.Pro, complexity of the project is only limited by programmers coding and computational geometry knowledge. Similar method is suitable for Autodesk Robot Structural Analysis, where instead of MATLAB one uses Visual Basic, C# or C++ programming environment for scripting. Also, it works well with Excel Visual Basic macros. In all cases a good setup for optimization problems. In contrast to visual programming (Dynamo or Grasshopper 3D) requires more effort on geometry generation.