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Analysis of Main Types of Vibrations at a Bridge for Passer-Byes

The present paper deals with the dynamic mode analysis in different situations at a bridge projected for passer-byes, with the help of the AxisVM software. From the multiple studied modes of vibrations we are going to present the main vibrations which appear due to the self-weight of the bridge, due to complex forces (different loads), and also due to seismic forces (mode 1 and mode 9).

Keywords: *modal analysis, complex forces, seismic forces.*

1. The Bridge Designed for Passer-Byes

The bridge designed for passer-byes, a work of the authors illustrated in figure 1, is placed in the center of a topic-garden. The access of the passer-byes starts at the ground level, later is supported by concrete elements, then in an unconventional way has a cross-support, because finally it presents a medieval architect design.

Figure 1. Topic-garden with bridge

2. AxisVM – Finite Elements Software for Structural Calculations

AxisVM software is an integrated system of „visual modelling" with the help of which the designer can create a 3D model. The visual modelling permits a graphic follow-up of the whole modelling process and calculation, until the evaluation of the results.

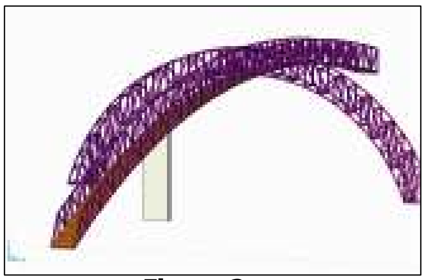

Figure 2.

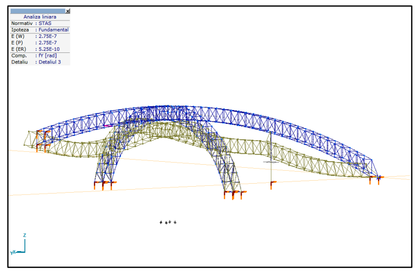

Figure 3.

AxisVM is a software based on the method of finite elements, designed for construction engineers. The static and dynamic analysis of the bi-dimensional structures as well as the tri-dimensional structures is made by linear and non-linear calculations. The software models structures of plain/spatial elements, plain/spatial beams, beams with resilient medium, sheaves with tensions, plain plates, plates with nerves, plates of resilient medium and structures of thin-curved plates (figure 2). The software permits dimensioning and checking of reinforcements and metal sections according to Romanian and European standards, seismic analysis according to P100/2006 (figure 3). For the modelling of the structures unlimited finite elements can be used and in free combination (ex. mixed structures of mediums and diaphragms).

3. Analysis of Main Types of Vibrations

In case of structures, the main types of dynamic vibrations are: free vibrations, self-vibrations, forced vibrations. The dynamic mode analyses can be very varied, from with simple modes to the most complex ones. The dynamic mode analyses carried out cover 9 modes, of which we present only the extreme (mode 9). The results are presented in tables.

3.1. Free vibrations

Free vibrations of a structure are those which appear after the cease of forces in action. In order to determine the free vibrations we have to know at a certain point of time the displacement and the initial speed at each grade of free dynamic.

The modes of vibration 1 and 9 of the bridge, considering just the permanent loads (weight G=189343.078)

Mode 1.

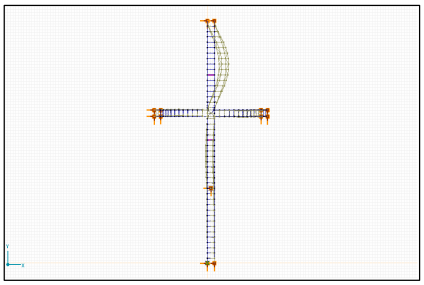

Figure 4.:Permanent Mode 1, (1.61 Hz), Upfront view.

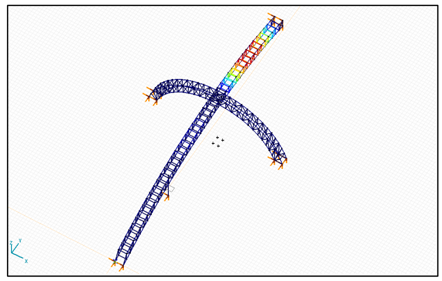

Figure 5.: Most solicited spots General view.

Table 2. Displacement [Permanent, Mode 1 (1.61 Hz)].

Nod	eX [mm]	eY [mm]	eZ [mm]	eR [mm]	fX [rad]	fY [rad]	fZ [rad]	fR [rad]
86	-0.041	0.002	-0.007	0.041	0.00013	-0.00689	-0.00088	0.00694
177	-0.041	-0.002	0.008	0.042	-0.00007	-0.00689	-0.00088	0.00694
56	0.325	0.001	0.026	0.326	-0.00004	0.02755	-0.00195	0.02762
194	0.004	-0.015	0.002	0.015	0.00177	0.00011	-0.00130	0.00219
260	0.004	0.015	-0.002	0.016	-0.00182	0.00003	-0.00141	0.00230
56	0.325	0.001	0.026	0.326	-0.00004	0.02755	-0.00195	0.02762
61	0.149	0	0.013	0.150	-0.00227	0.01468	0.03050	0.03393

- maximum displacement: 0.326 mm < 75 mm;
- vibration period calculation: T = 1/f, T = 1/1,61 = 0,62 s;
- most solicited point is node 56;

Mode 9.

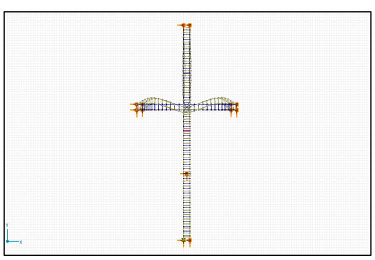

Figure 6.: Permanent Mod 9, (4,28 Hz), Upfront view.

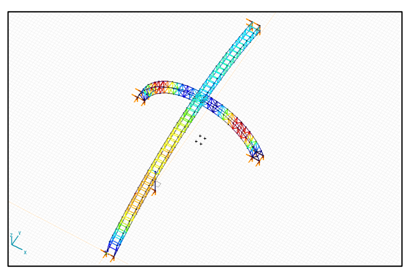

Figure 7.: Most solicited spots, General view.

Table 3. Displacement [Permanent, Mode 9 (4,28 Hz)].

Nod	eX [mm]	eY [mm]	eZ [mm]	eR [mm]	fX [rad]	fY [rad]	fZ [rad]	fR [rad]
10	-0.021	-0.062	0.021	0.068	-0.00079	0.01853	-0.00120	0.01859
55	0.032	-0.060	0.018	0.070	-0.00083	0.02139	-0.00220	0.02152
146	0.032	-0.060	-0.027	0.073	-0.00082	0.02139	-0.00220	0.02152
94	0	-0.058	0.094	0.111	-0.00017	-0.05003	-0.02350	0.05528
196	-0.012	0.158	-0.005	0.159	-0.00569	-0.00035	0.00316	0.00651
94	0	-0.058	0.094	0.111	-0.00017	-0.05003	-0.02350	0.05528

- maximum displacement: 0.159 mm < 75 mm;
- vibration period calculation: T = 1/f, T = 1/4,28 = 0,23 s;
- most solicited point is node 196;

3.2. Self-vibrations

Self-vibrations result from forces which act on structures. In our case these are permanent loads, useful loads, wind loads and snow loads. The modes of vibrations 1 and 9 for the bridge load by:

- Permanent loads (self-weight);
- Useful loads;
- Snow loads;
- Wind loads;

are presented in figures 8 and 9.

Mode 1

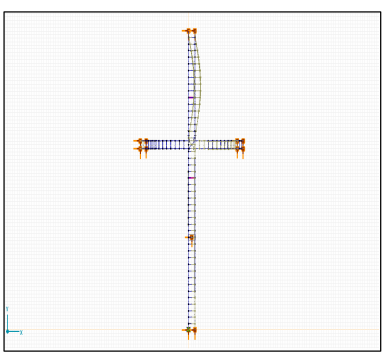

Figure 8.: Basic Mode 1, (0,79 Hz), Upfront view.

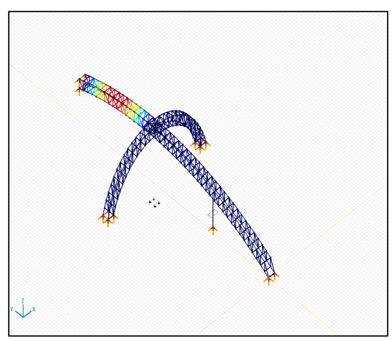

Figure 9.: Most solicited parts, General view.

Table 4. Displacement [Basic, Mode 1 (0,79 Hz)].

Nod	eX [mm]	eY [mm]	eZ [mm]	eR [mm]	fX [rad]	fY [rad]	fZ [rad]	fR [rad]
86	-0.012	0.001	-0.003	0.012	0.00001	-0.00216	-0.00025	0.00218
177	-0.012	-0.001	0.003	0.012	0.00001	-0.00216	-0.00025	0.00218
223	0.001	-0.005	0	0.005	0.00070	0.00001	-0.00050	0.00085
260	0.002	0.005	-0.001	0.006	-0.00071	0.00007	-0.00052	0.00088
56	0.150	0	0.008	0.150	0	0.00747	-0.00032	0.00748
62	0.040	-0.001	0.003	0.040	-0.00075	0.00189	0.01509	0.01523
153	0.040	0.001	-0.003	0.040	0.00074	0.00189	0.01509	0.01523

- maximum displacement: 0.150 mm < 75 mm;
- vibration period calculation: T = 1/f, T = 1/0,79 = 1,26 s;
- most solicited point is node 56;

Mode 9.

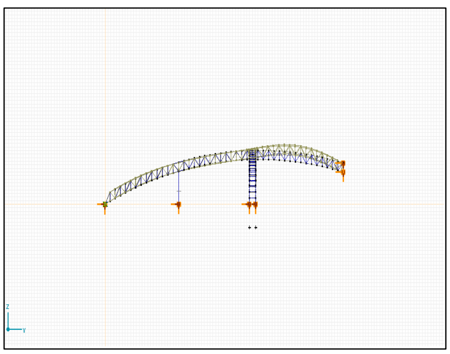

Figure 10.: Basic Mode 9, (2,39 Hz), Upfront view.

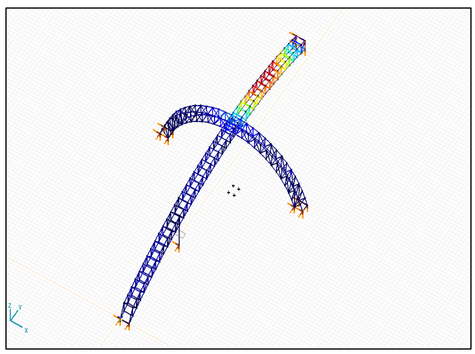

Figure 11.: Most solicited parts, General view.

Table 5. Displacement [Basic, Mod 9 (2,39 Hz)].

Nod	eX [mm]	eY [mm]	eZ [mm]	eR [mm]	fX [rad]	fY [rad]	fZ [rad]	fR [rad]
133	-0.002	-0.002	-0.016	0.016	-0.00012	0.00103	-0.00007	0.00104
12	0.001	-0.004	0.128	0.128	0.00059	0.00839	-0.00082	0.00845
55	0.023	-0.006	0.128	0.130	0.00081	0.00880	-0.00113	0.00891
20	-0.002	-0.039	0.022	0.045	-0.01374	0.00081	-0.00049	0.01377

- maximum displacement: 0.130 mm < 75 mm;
- vibration period calculation: T = 1/f, T = 1/2,39 = 0,41 s;
- most solicited point is node 55;

4.3. Forced vibration

These are vibrations produced by perturbating harmonious forces, sequenced or random. In case of forced vibrations the dynamic action is studied, applied indirectly (seismic) on the bridge. The vibration modes 1 and 9 of the bridge, when seismic loads are considered, are presented in figure 12 and 13.

Mode 1.

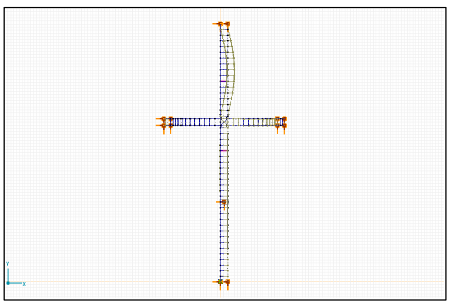

Figure 12.: Seismic Mode 1**,** (1,28 Hz), Upfront view.

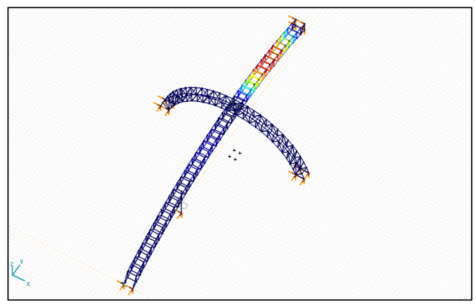

Figure 13.: Most solicited parts, General view.

Table 6. Displacement [Seismic, Mode 1 (1,28 Hz)].

Nod	eX [mm]	eY [mm]	eZ [mm]	eR [mm]	fX [rad]	fY [rad]	fZ [rad]	fR [rad]
86	-0.024	0.001	-0.005	0.024	0.00005	-0.00418	-0.00050	0.00421
56	0.249	0.001	0.017	0.250	-0.00001	0.01603	-0.00094	0.01605
147	0.249	-0.001	-0.016	0.250	-0.00002	0.01603	-0.00094	0.01605
194	0.003	-0.010	0.002	0.010	0.00123	0.00012	-0.00089	0.00152
56	0.249	0.001	0.017	0.250	-0.00001	0.01603	-0.00094	0.01605
61	0.115	0	0.008	0.115	-0.00146	0.00896	0.02381	0.02548

- maximum displacement: 0.250 mm < 75 mm;
- vibration period calculation: T = 1/f, T = 1/1,28 = 0,78 s;
- most solicited point is node 56;

Mode 9.

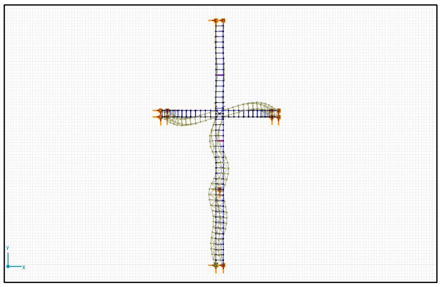

Figure 14. Seismic Mode 9, (3,71 Hz), Upfront view.

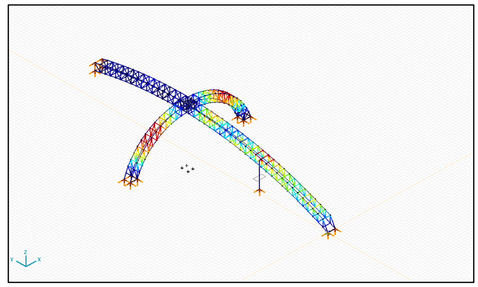

Figure 15. Most solicited parts, General view.

Table 7. Displacement [Seismic, Mode 9 (3,71 Hz)].

Nod	eX [mm]	eY [mm]	eZ [mm]	eR [mm]	fX [rad]	fY [rad]	fZ [rad]	fR [rad]
261	-0.012	-0.179	0.008	0.180	0.00824	-0.00058	0.00559	0.00998
76	-0.142	0.018	-0.066	0.158	0.00089	-0.06897	-0.00554	0.06920
167	-0.142	-0.018	0.066	0.158	-0.00103	-0.06897	-0.00554	0.06920

- maximum displacement: 0.180 mm < 75 mm;
- vibration period calculation: T = 1/f, T = 1/3,71 = 0,26 s;
- most solicited point is node 261;

4. Conclusion

In this paper we presented the results of mode analysis order I and the analysis of main types of vibrations at a bridge designed for passer-byes with the help of AxisVM software, with the objective to determine the frequences, self-vibration modes and mode moves.

Within mode analysis order I the effect of the streching/compression forces on the stiffness of the elements were not taken into account while determining the vibration modes. In mode analysis order II streching forces increase the stiffnes of the elements, and the compression forces decrease stiffness. This phenomenon influences the results of the mode analysis. In all cases, with this type of analyses the results of a static hypothesis are used.

Within the structure analysis the software determines self positive values, self values close to zero cannot be determined.

The results of the analysis show that we have smaller move values than the admitted values of 75 mm and we can conclude that our bridge would last.

References

[1] Alexiu, I. etc.: *Poduri,* E.D.P., Bucureşti, 1973.

[2] Bejan, Mircea: *Rezistenţa materialelor vol.1. şi vol. 2,* Editura AGIR Bucureşti şi Editura MEGA Cluj-Napoca, 2009.

[3] Bullington, P: *The Tower and the Bridge,* Princeton University, New Jersey, 1983.

[4] Chira, Nicolae etc.: *Cadre metalice spaţiale semirigide*, Editura U. T. Pres, Cluj- Napoca, 2002.

[5] Comşa, Dan-Sorin: *Metoda elementelor finite*, Curs introductiv, Editura U.T.Pres, Cluj- Napoca, 2007.

[6] *** - Reglementare tehnică ,,Cod de proiectare. Bazele proiectării structurilor în construcţii", indicativ CR 0-2005 din 27/12/2005, Publicat în Monitorul Oficial, Partea I nr. 148 bis din 16/02/2006.

[7] *** - *Reglementări tehnice* ,,Cod de proiectare. Evaluarea acţiunii zăpezii asupra construcţiilor", indicativ CR 1-1-3-2005, Publicat în Monitorul Oficial pe 16/02/2006.

[8] *** - *Reglementare tehnică* ,,Cod de proiectare. Bazele proiectării şi acţiunii asupra construcţiilor. Acţiunea vântului", indicativ NP 082-04-2005, Publicat în Monitorul Oficial din 25/04/2005.

[9] *** - *Prevederi de proiectare*, Universitatea Tehnică de Construcţii, Bucureşti, ,,Cod de proiectare seismică P-100, Partea I, P-100-2/2006, Contract 174/2002, Redactarea a IV-a, august 2006.

[10] www.AxisVM - *Program de elemente finite pentru calculul structurilor*

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