The Aseismic Upgrading of the Structures in the "Grande Albergo" Hotel – Potenza (Italy)

REMARKS IN THE LIGHT OF THE NEW RESEARCHES

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INTRODUCTION

As you can read in the initial paper (pag.12) *the calculation*[1] *were carried out in accordance with the Italian code being considered by a static analysis* and *no account was taken of such favourable factors* etc. and again *with the unit weights and the total weights per each floor structure determined, together with the corresponding horizontal forces, corrected bye the prescribed storey coefficients, the stresses in the individual rods in each aseismic frame, induced by external and prestressing forces, were computed. These were calculated by solving the force-balance and strain-congruence equations, without any very laborious development : at most a system of three linear equations had to be resolved.*

The stress distribution in the aseismic frame was also calculated using the computer (mainframe), the result obtained being in excellent agreement with those got by traditional means.

It was found though that the computer calculations, formulated without taking account of the static scheme symmetry, provided somewhat less approximate results, considering the greater complexity of the processing demanded.

It is an obvious occurrence of the old methods for which the key role was played by the experience and the professionalism of the authors[2].

At that time the PC (Personal Computer) was not on offer. On the contrary, in the ARCHSTUDIO Office in Potenza (Arch.A.Costabile, Eng.M.Leggeri), a mainframe Hewlett Packard 3000, was available, but with Software of ancient times. Despite the significant efforts [1], the outdated methodology, didn't allow to develop a dynamic analysis of structures[3]. Neither it was possible to evaluate the real PGA's (Peak Ground Accelerations) suffered by the (old) structures during the EQ of November 1980[4] and new ones during the EQ of May 1990.

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[1] The calculation began in the year 1982.

[2] M.Leggeri was the youngest in the group, even so, at that time were elapsed 25 years since his Doctorate in Civil Engineering.

[3] New targets for software [2], [3], [4] were obtained some year after.

[4] It was applied the Italian Code after the (late) introduction of Potenza area in the official seismic zones.

EFFECTS OF LAST EARTHQUAKES

The earthquake of November 23,1980 that had struck the region was very strong, with Richter Magnitude 6.8 (MMI=8, MCS=11)[5], and the epicenter evaluated 43.9 Km from Potenza. We don't have strong motion records for this EQ in Potenza area; therefore we can apply the laws of attenuation for the Southern Appennines (Grandori et alii, 1991 [7]) as well as the correlation between MCS intensity and peak of horizontal acceleration to the ground (PGA) for Southern Italy:

(1) **MCS(local) = - 1.338 + 1.489 * MCS(epicentral) - 1.608 * Log $_e$(Distance,Km)**

(2) **Log $_{10}$ PGA =0.1805 * MCS - 2.222** (1) ***See Book*** [6] [13], page 93, 97

So we could evaluate for Potenza a horizontal **PGA=0.270**, very dangerous for all the existent edifices, which have built without any coverage for the seismic forces[7].
After the completion of the Aseismic Upgrading, the city Potenza suffered a new quake (May 5, 1990) with Richter Magnitude 5.4 (MMI=6.6, MCS=8), and the epicenter evaluated only 4.9 Km and estimated **PGA =0.167**, close to the value of Italian Seismic code for the 2nd category, provided for this area only after EQ of 1980.
The behaviour of the building was excellent, without any damage for the structures.

DYNAMIC ANALYSIS OF THE STRUCTURES

The Student Giuseppe Rosa, in 1998, developed a Doctoral Theses in Civil Engineering, University of Basilicata, Potenza (Co-Supervisor M.Leggeri), with a full analysis of the structures of "Grande Albergo" Hotel [15].
For this exhaustive approach was used the program SAP-90, with the static scheme shown in Fig. 1, ***in which the existing shear walls were modelled through diagonal rods.***

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[5] In the historical catalog of EQs, available in Italy, the events are reported in MCS scale (Mercalli, Cancani, Sieberg).
[6] It is possible to consult the book (written in Italian Language), at the EERC Library, NISEE, Richmond, Ca.
[7] Any local amplifications due to Soil-Structure Interaction is excluded, because the bed-rock of Potenza is composed of over consolidated Pleistocene clay.

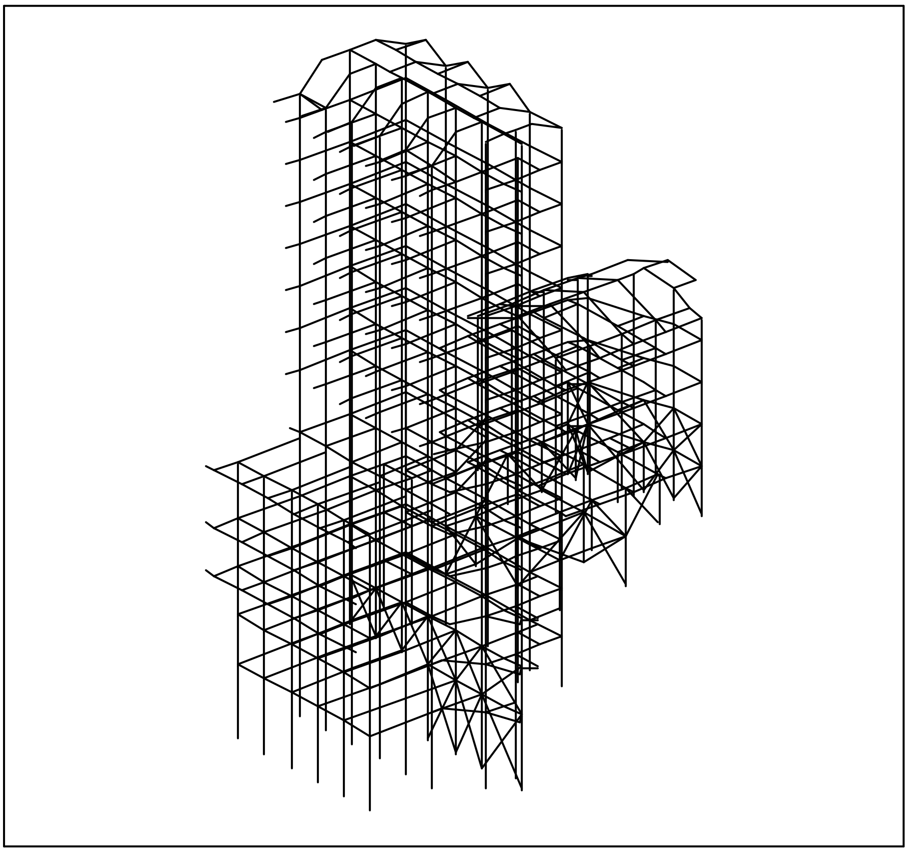


Fig. 1 – Structural scheme

The final results of processing are :

MODE NUMBER	EIGENVALUE $(RAD/SEC)^2$	CIRCULAR FREQ (RAD/SEC)	FREQUENCY (CYCLES/SEC)	PERIOD (SEC)
1	.107069E+02	.327214E+01	.520777	1.920209
2	.217516E+02	.466386E+01	.742277	1.347207
3	.472311E+02	.687249E+01	1.093791	.914252
4	.124741E+03	.111688E+02	1.777563	.562568
5	.233674E+03	.152864E+02	2.432906	.411031
6	.304296E+03	.174441E+02	2.776312	.360190
7	.385098E+03	.196239E+02	3.123243	.320180
8	.543808E+03	.233197E+02	3.711444	.269437
9	.928078E+03	.304644E+02	4.848556	.206247
10	.958393E+03	.309579E+02	4.927108	.202959
11	.145305E+04	.381189E+02	6.066810	.164831
12	.161079E+04	.401346E+02	6.387619	.156553
13	.225455E+04	.474821E+02	7.557008	.132327
14	.249450E+04	.499449E+02	7.948982	.125802
15	.384475E+04	.620061E+02	9.868570	.101332
16	.425128E+04	.652019E+02	10.377201	.096365
17	.442049E+04	.664868E+02	10.581696	.094503
18	.499577E+04	.706808E+02	11.249194	.088895
19	.558057E+04	.747032E+02	11.889382	.084109
20	.665850E+04	.815997E+02	12.986990	.077000
21	.697824E+04	.835358E+02	13.295142	.075215
22	.844148E+04	.918775E+02	14.622764	.068387
23	.871269E+04	.933418E+02	14.855804	.067314
24	.107391E+05	.103629E+03	16.493143	.060631
25	.119426E+05	.109282E+03	17.392799	.057495
26	.121410E+05	.110186E+03	17.536661	.057023
27	.135036E+05	.116205E+03	18.494593	.054070

P A R T I C I P A T I N G   M A S S - (percent)

MODE	X-DIR	Y-DIR	Z-DIR	X-SUM	Y-SUM	Z-SUM
1	33.420	.104	00.000	33.420	.104	00.000
2	1.836	14.106	00.000	35.255	14.210	00.000
3	.226	39.276	00.000	35.481	53.486	00.000
4	15.770	.087	00.000	51.252	53.573	00.000
5	2.664	4.437	00.000	53.916	58.010	00.000
6	.232	19.916	00.000	54.148	77.925	00.000
7	13.464	.143	00.000	67.612	78.069	00.000
8	.342	.542	00.000	67.954	78.611	00.000
9	.756	2.806	00.000	68.710	81.417	00.000
10	4.522	1.027	00.000	73.232	82.444	00.000
11	4.025	.032	00.000	77.257	82.476	00.000
12	1.600	.058	00.000	78.858	82.533	00.000
13	.947	.001	00.000	79.805	82.534	00.000
14	.007	.878	00.000	79.812	83.412	00.000
15	.491	.350	00.000	80.302	83.762	00.000
16	1.427	.514	00.000	81.729	84.277	00.000
17	.004	.184	00.000	81.733	84.461	00.000
18	.035	5.809	00.000	81.768	90.270	00.000
19	.244	2.781	00.000	82.012	93.051	00.000
20	3.039	.026	00.000	85.051	93.077	00.000
21	2.268	.535	00.000	87.319	93.612	00.000
22	6.596	.325	00.000	93.916	93.936	00.000
23	.001	.033	00.000	93.917	93.969	00.000
24	.010	.000	00.000	93.926	93.970	00.000
25	.014	.501	00.000	93.940	94.471	00.000
26	1.144	.017	00.000	95.085	94.487	00.000
27	.405	.346	00.000	95.490	94.833	00.000

The graphic representations of the first three vibration modes are shown in Fig. 2 – 3 – 4) :

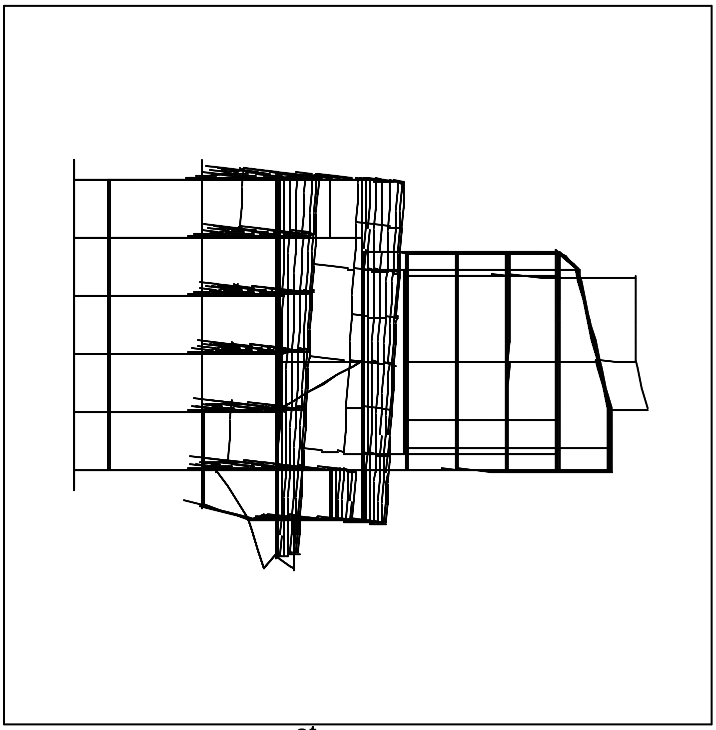


Fig. 2 – 1st vibration mode

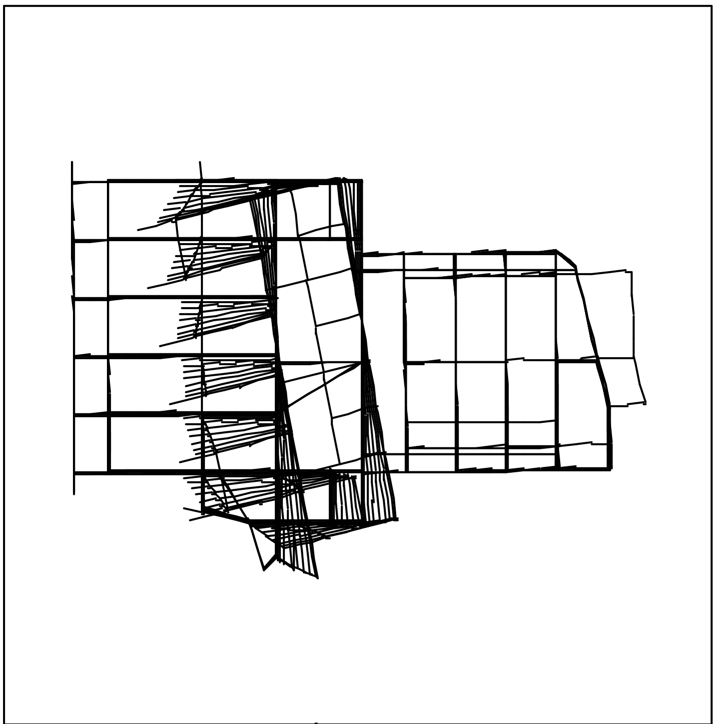


Fig. 3 – 2nd vibration mode

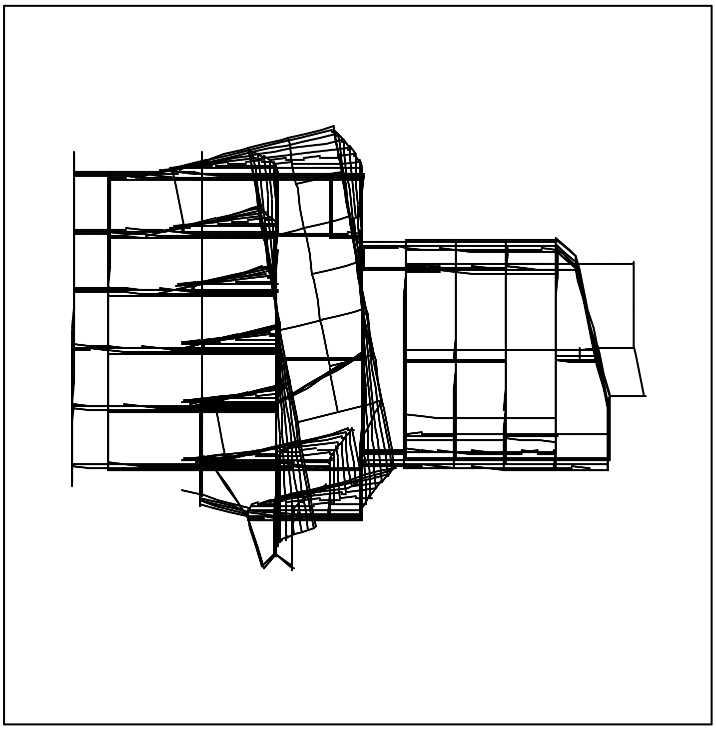


Fig. 4 – 3rd vibration mode

After the upgrade, the structural scheme of the assembled reinforcement is in Fig. 5 :

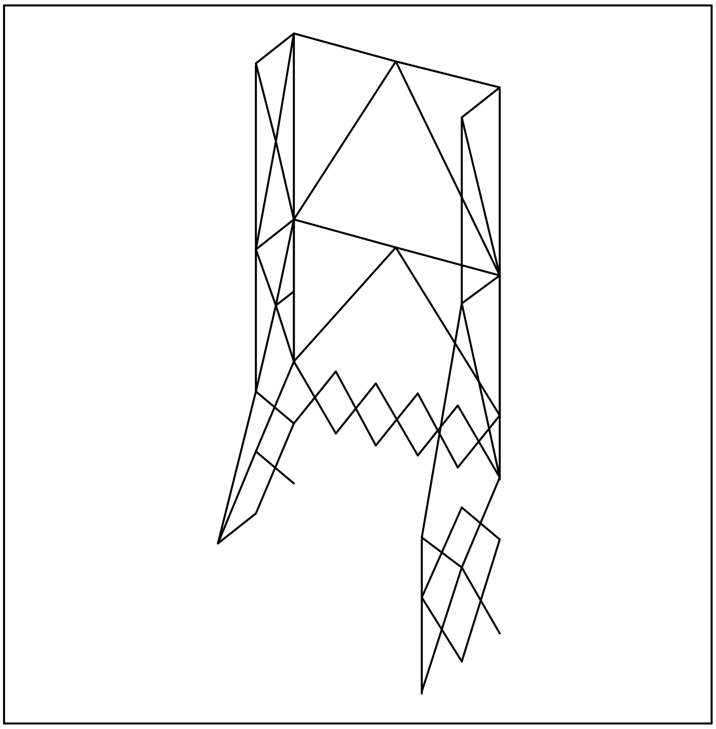


Fig. 5 – Scheme of the new Structures (Three frames)

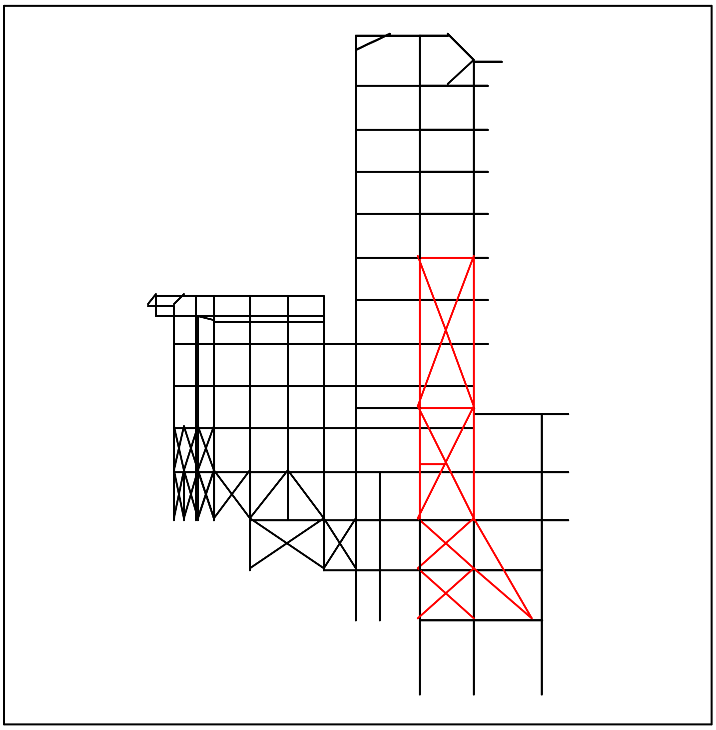


Fig. 6 – Insertion of frame 1

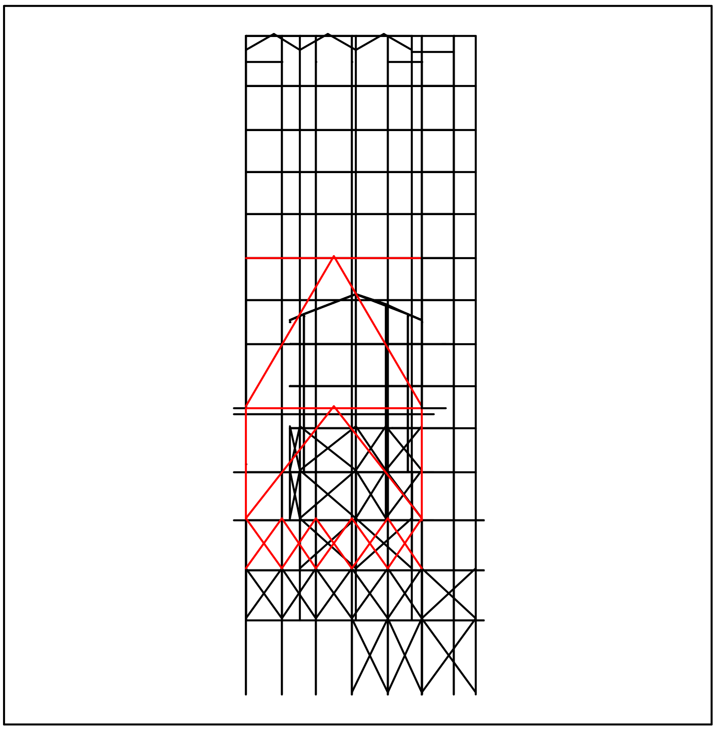


Fig. 7 - Insertion of frame 2

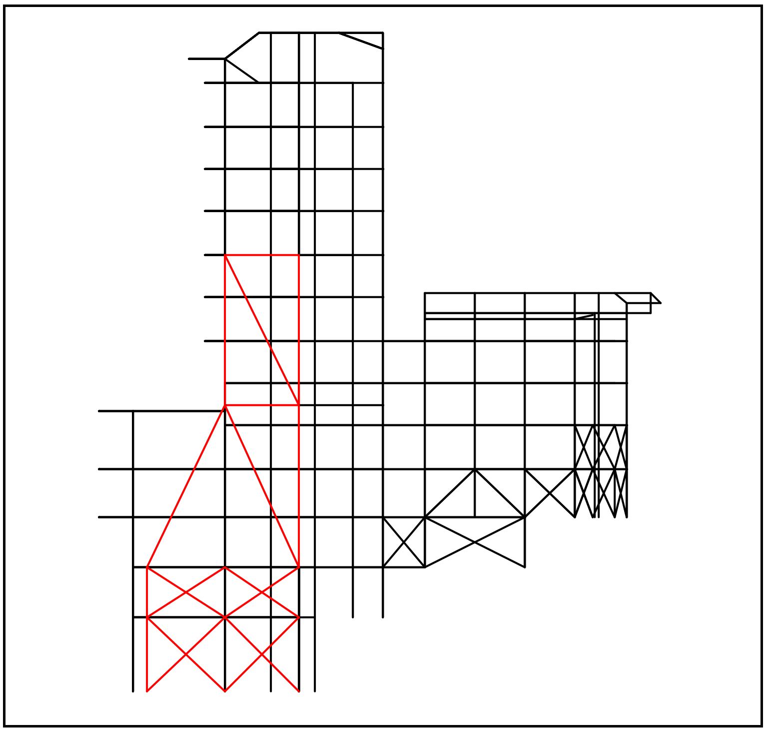


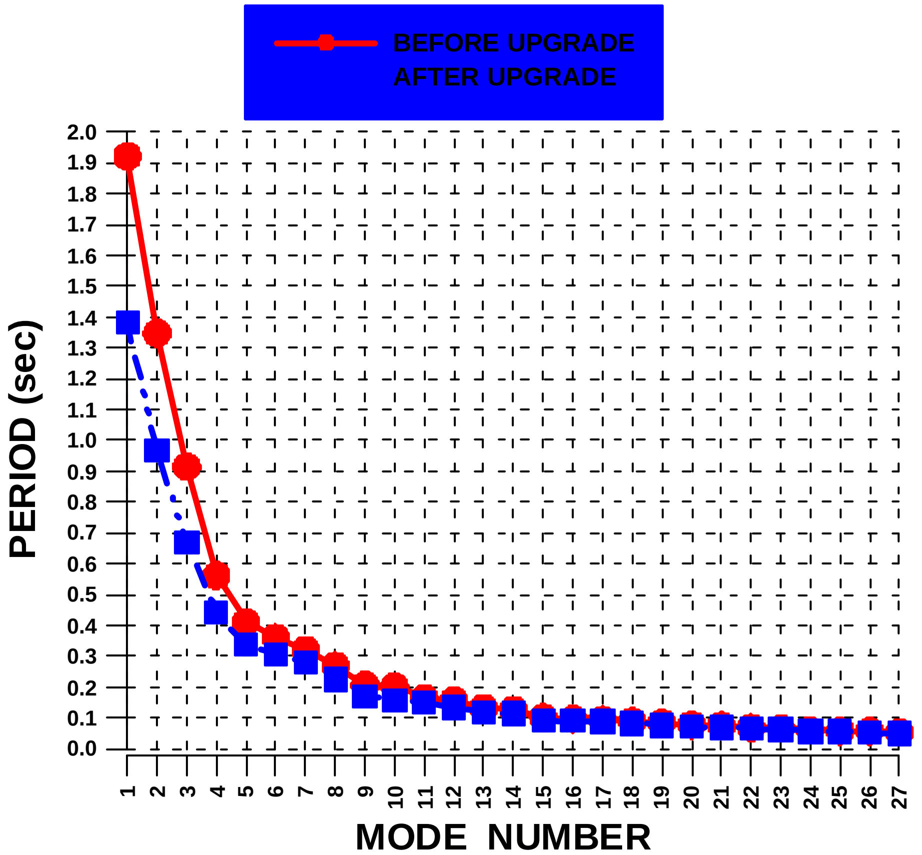
Fig. 8 - Insertion of frame 3

The final results of new processing are :

MODE NUMBER	EIGENVALUE $(RAD/SEC)^2$	CIRCULAR FREQ (RAD/SEC)	FREQUENCY (CYCLES/SEC)	PERIOD (SEC)
1	.206243E+02	.454140E+01	.722786	1.383536
2	.423136E+02	.650489E+01	1.035285	.965918
3	.884938E+02	.940711E+01	1.497189	.667918
4	.201649E+03	.142003E+02	2.260049	.442468
5	.345416E+03	.185854E+02	2.957952	.338072
6	.414928E+03	.203698E+02	3.241951	.308456
7	.497843E+03	.223124E+02	3.551128	.281601
8	.782107E+03	.279662E+02	4.450956	.224671
9	.138974E+04	.372792E+02	5.933176	.168544
10	.156911E+04	.396120E+02	6.304449	.158618
11	.171243E+04	.413815E+02	6.586066	.151836
12	.219748E+04	.468772E+02	7.460745	.134035
13	.274621E+04	.524043E+02	8.340399	.119898
14	.301141E+04	.548763E+02	8.733840	.114497
15	.456883E+04	.675931E+02	10.757775	.092956
16	.475287E+04	.689410E+02	10.972306	.091139
17	.495005E+04	.703566E+02	11.197597	.089305
18	.575526E+04	.758634E+02	12.074040	.082822
19	.678012E+04	.823415E+02	13.105052	.076306
20	.759950E+04	.871751E+02	13.874354	.072075
21	.795042E+04	.891651E+02	14.191070	.070467
22	.915209E+04	.956666E+02	15.225809	.065678
23	.991453E+04	.995717E+02	15.847337	.063102
24	.123667E+05	.111206E+03	17.698923	.056501
25	.127801E+05	.113049E+03	17.992320	.055579
26	.145832E+05	.120761E+03	19.219701	.052030
27	.156394E+05	.125057E+03	19.903515	.050242

P A R T I C I P A T I N G   M A S S - (percent)

MODE	X-DIR	Y-DIR	Z-DIR	X-SUM	Y-SUM	Z-SUM
1	29.122	.001	00.000	29.122	.001	00.000
2	.733	4.628	00.000	29.855	4.629	00.000
3	.112	43.187	00.000	29.967	47.816	00.000
4	30.369	.191	00.000	60.336	48.007	00.000
5	.267	5.710	00.000	60.603	53.716	00.000
6	.643	24.922	00.000	61.246	78.638	00.000
7	8.586	.428	00.000	69.832	79.066	00.000
8	.010	.556	00.000	69.842	79.622	00.000
9	.627	.045	00.000	70.468	79.667	00.000
10	1.089	2.483	00.000	71.557	82.150	00.000
11	6.139	.037	00.000	77.696	82.187	00.000
12	.359	1.994	00.000	78.056	84.180	00.000
13	4.381	.157	00.000	82.437	84.337	00.000
14	.335	2.645	00.000	82.773	86.983	00.000
15	.123	1.633	00.000	82.896	88.616	00.000
16	.493	1.159	00.000	83.389	89.775	00.000
17	1.151	.105	00.000	84.540	89.880	00.000
18	.057	.000	00.000	84.597	89.880	00.000
19	.202	1.819	00.000	84.800	91.700	00.000
20	.137	2.901	00.000	84.937	94.600	00.000
21	3.221	.015	00.000	88.158	94.615	00.000
22	.249	.019	00.000	88.407	94.634	00.000
23	5.522	.111	00.000	93.929	94.745	00.000
24	.728	.038	00.000	94.657	94.783	00.000
25	.305	.546	00.000	94.962	95.329	00.000
26	.581	.603	00.000	95.543	95.932	00.000
27	.000	.667	00.000	95.543	96.599	00.000



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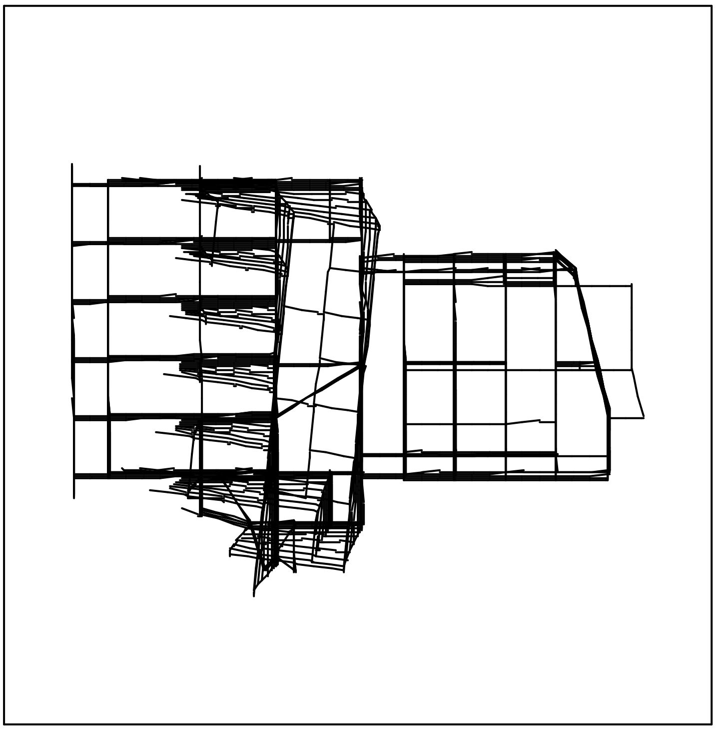

Fig. 9 - – 3rd vibration mode (After Upgrade)

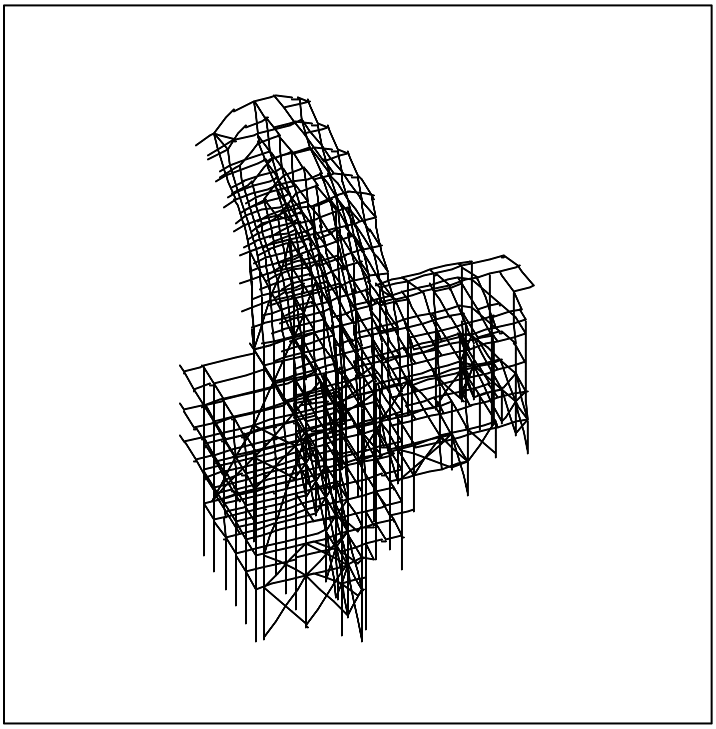

Fig. 10 - – 1st vibration mode (After Upgrade)

CONCLUSIONS

The dynamic analysis shows the different behaviour of the tower after the upgrade : the height of the deformable structure starts at the top of new frames.

In addition, an effective test was offered by the earthquake of May 1990, without any damage, whereas in other buildings of the town the collapses were numerous.

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