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# SIMULATION OF SEA CURRENT VORTEX SHEDDING INDUCED VIBRATIONS IN THE NEMO TOWER

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## 1 SHORT ABSTRACT

This paper presents the basic principles and the main features of the analysis performed in order to simulate the dynamic behavior of the underwater neutrino telescope Nemo with particular reference to marine current vortex induced vibrations.

## 2 INTRODUCTION

The NEMO project is concerned with an underwater Cherenkov telescope looking for high energy neutrinos. The reason why scientists are interested in neutrinos is that neutrinos can reveal us the secrets of the engine of an Active Galactic Nucleus (AGN). Active galactic nuclei are extremely powerful sources of radiation and particles which travel the entire universe. Since protons are deflected or adsorbed during their journey in the space and electromagnetic radiation is strongly absorbed, only neutrinos may come from the deepest space to the earth. Sea depths are the most suitable environment to place a telescope because of very low biological and electrical activities.

The aim of the NEMO project is to design the so called KM3Net,a neutrino telescope equipped with 4096 light detectors distributed in a volume of at least one cubic kilometre at the bottom of the Mediterranean Sea. Several sites have been investigated in the Mediterranean Sea.The site of Capo Passero (35° 50' N, 16° 10' E) in the Jonian sea revealed very appealing due to the presence of a flat bathimetric profile (> 10 km$^2$) at 3300 m depth and 80 km from the Sicily coast. Several measurement campaigns performed in this site highlighted very low biological activity and both sedimentation rate and fouling rate are very low. Numerous current meters were also placed in the site (August 1998 – running) in order to provide a statistical database. The expected maximum value of current velocity is 10 cm/s with an average current intensity of 3.6 cm/s and a 2.5 cm/s RMS.

The NEMO telescope layout is based on a squared array of 64 underwater vertical floating structures - named *towers* - ballasted at the seabed level. Each tower is 600 m high and is equipped with 64 optical modules. The distance among towers is 200 m and the telescope may achieve more than 2km$^2$ trigger area.

Each tower (fig. 1) is a slender structure composed by modular sub-structures (named *floors* in the following) connected by means of cables having different tensions and lengths.

The tower is 780m high, and is equipped with 16 floors of 15m length; the distance between floors is 40m while the distance between the seabed and the lowest floor is 150m. A buoy is placed at the top of the tower to provide cables tensioning.

When designing a slender marine structure for a deepwater application, marine current effects on the structural behavior are a major concern with respect to both static and dynamic conditions.

With particular reference to the design of the Nemo Tower structure, characterized by a large flexibility, Vortex Induced Vibrations (VIV) must be carefully evaluated because of the possible occurrence of marine currents and the large uncertainties in the evaluation of environmental conditions. The combination of these factors can lead to vibrations that may significantly reduce the structure operative performance and a design optimization should be carried out. As well known, VIV come from “lock-in” phenomena that cause the vortex shedding frequency (depending on the flow velocity and the geometrical shape of the structure) tuning on the natural frequencies of the structure itself. The skill to predict the occurrence of VIV under a large spectrum of operating conditions is hence a major factor for the success of the design process.

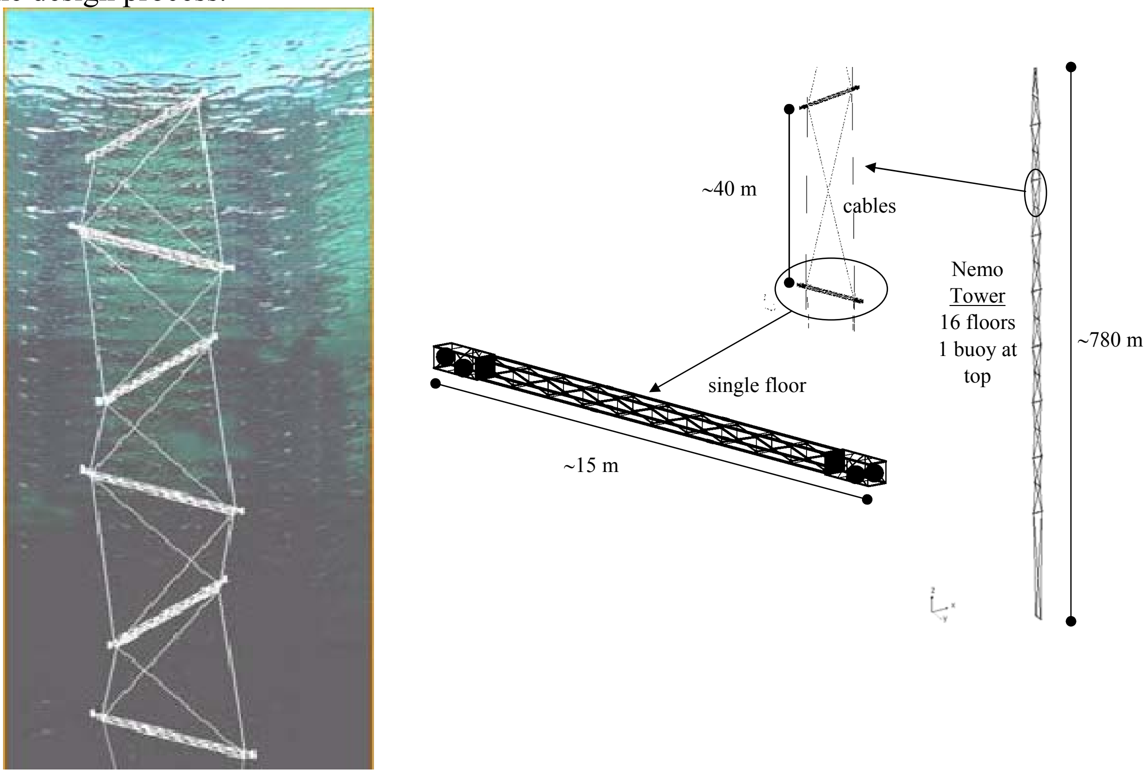



Figure 1: Sketch of the Nemo Tower.

The aim of this paper is to present the research activities carried out by the authors in order to assess the dynamic behavior of the underwater telescope Nemo with particular reference to marine current vortex induced vibrations. Preliminary results are presented and future activities are outlined.

## 3 NUMERICAL MODEL OF THE NEMO TOWER AND VIV ANALYSIS

In order to predict the VIV effects on the Nemo Tower in operating conditions, a time domain numerical model which takes into account the structural behavior of the floors and the connecting cables has been developed by means of multibody system dynamics. Due to the main feature of the VIV phenomena, structure natural frequencies and modal shapes evaluation is fundamental. Moreover NEMO tower is concerned by different type of modal shapes i.e global, local and coupled (as shown in figures 2-4).

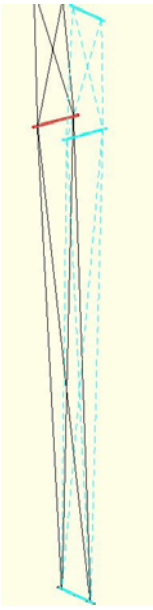
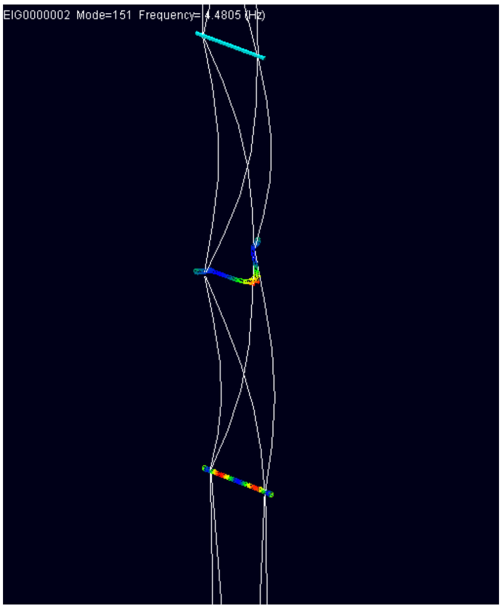


Figure 2



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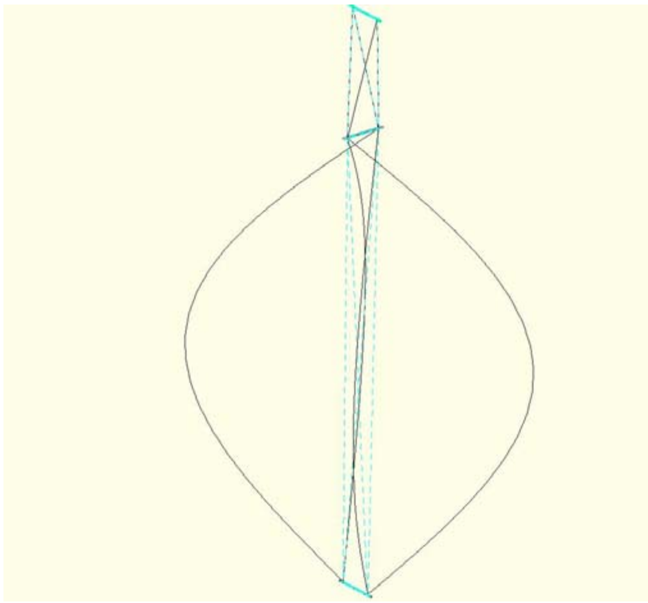
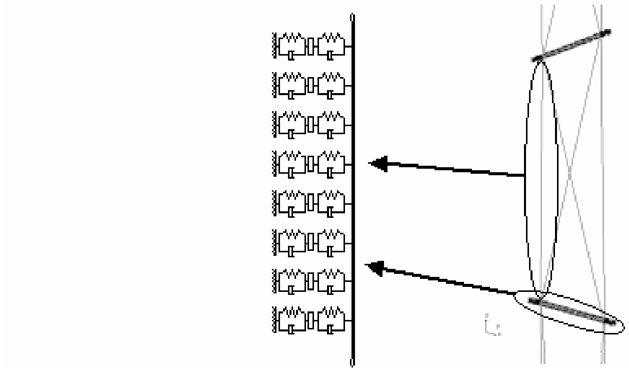


Figure 4:

The tower static equilibrium under constant marine current was evaluated by using ESDU standard flow drag forces, keeping into account actual tension distribution resulting from structure weight and buoyancy effects. Starting from different static positions, the eigenmodes of the whole tower were computed. Vortex shedding effects are reproduced by means of equivalent oscillators technique ([1] [2] [3]). The equivalent oscillator is a non-linear 1 d.o.f. system which transmits to the structure the same forces produced by the vortex shedding phenomena. A distribution of forces generated by equivalent oscillators is then applied in specific markers of the multibody model of the structure in order to reproduce the dynamic effects of vortex shedding forces both on ropes and floors (fig. 5). As far as equivalent oscillator parameters values are concerned, a large amount of work has been carried out by the authors in previous researches with particular reference to structures with cylindrical shapes like overhead lines [2], submarine cables [1] or offshore drilling and production marine risers [3]. Equivalent oscillator parameters have been identified by means of wind tunnel test of cylindrical sectional models and these parameters have been used for oscillator distribution concerning cables. Presently the same parameters have been used also for the oscillators applied to the floor which is basically a square cluster of 4 cylinders with pitch/diameter ratio of about 6; it should be noted that floor vortex shedding mast be investigated in more details because of its particular topology (fig.5).

Assuming a Strouhal number of 0.2 both for cables and floors, several natural frequencies of the NEMO tower are potentially locked by vortex shedding phenomena. Several preliminary numerical analysis have been performed considering different marine current profiles. As an example figs 7and 8 show respectively cable and floor vortex induced vibration (expressed as amplitude/diameter ratio) due to maximum current intensity from NW direction. In both cases 40% diameter vibration amplitude are shown.



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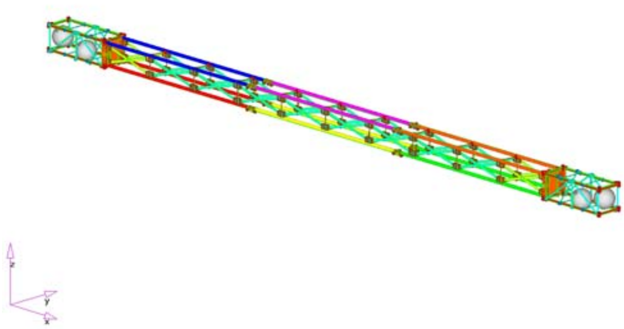

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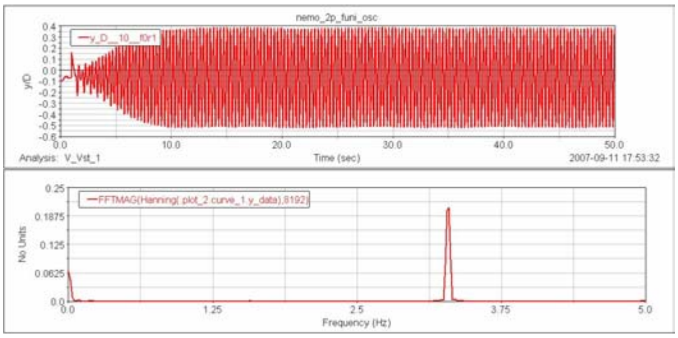


Figure 7

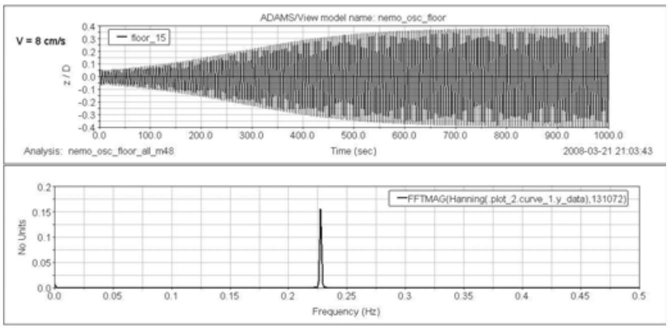


Figure 8

## 4 CONCLUSION AND FUTURE DEVELOPEMENTS

The underwater NEMO telescope tower VIV due to marine current has been investigated by means of a numerical model developed by the authors. In order to improve mathematical model reliability some wind tunnel tests are scheduled in the next future using a carbon fiber manufactured sectional scaled model of the Nemo tower floor in order to evaluate the Strouhal frequency and the vortex shedding behavior of this unconventional geometry.

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