Issue 10 - July 2003

newsletter

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of the European Commission

SAMCO NEWS

Structural Assessment Monitoring and Control Issue 10 July 2003

contents

Published by VCE.

Summer Academy

■ Date:

14-18. July, 2003.

■ Venue:

Robinson College
Cambridge University

Grange Road
Cambridge CB3 9AN
UK.

■ Refunding of fee

There is a special funding for students and NAS participants, which fully cover the cost for the admission at the academy.

Homepage:
http://www.samco.org/academy

For questions please contact:
Mrs. Krims-Steiner (VCE)
krims-steiner@vce.at.

■ Registration:

Please fill in the registration form, offered at:

www.samco.org/download/reg_acad.doc

We kindly ask you to fill it in electronically, then print and sign it and send it via FAX (number given on the form) to VCE.

■ Programme

Please refer to the programme provided under: www.samco.org/academy.

SAMCO Summer Academy

What is this Summer Academy About?

The SAMCO Summer Academy is a presentation of the current practice in monitoring assessment and control of structures.

This one week program focuses on the effective use and understanding of the related methods and tools. The program has been designed to be highly practical and includes parallel sessions to distinguish between more practical oriented or more theoretical oriented participants. All sessions include extensive discussion periods to give participants the chance to put the knowledge they have gained into practice. Successful technologies will be demonstrated and explained in detail.

A Practical One Week Academy Event Focussing on:

- Which monitoring technique should be used for different types of projects
- Find the best suitable method for your application
- Which assessment methods are available and what are the criteria
- The theoretical background for the current practice
- Inside information from key players worldwide
- Meeting with the European Commission, DG Research discussing the 6th Framework Program
- introduction to structural monitoring and how it works in practice
- Relationship between monitoring, assessment and risk allocation

Venue - Robinson College

The Academy will take place at the Robinson College of the world-renowned Cambridge University: Within the popular and beautiful City of Cambridge, Robinson College provides a unique environment for national and international conferences. From the outset Robinson College was planned with the needs of conferences very much in mind. Set in several acres of attractive wooded gardens yet only a few minutes' walk from the city centre and the famous 'Backs', the College building is architecturally striking and highly functional.

The College has been a venue for residential and non-residential conferences and meetings since 1981 and over the years has steadily grown in experience and reputation.

Who should attend?

Owners of structures
Contractors
Consulting engineers
All those involved in international construction projects
All those involved in assessment of structures
Facility managers
Maintenance oriented companies
Owners of plants and equipment
Construction managers
Insurance companies
Funding agencies
Operators of nuclear power plants
Industrial Plant operators
Researchers interested in the topics
Parties interested in participation on European research projects

Auditorium– Robinson College

The large air-conditioned Auditorium of the Robinson College with a raked floor and maximum seating capacity of 270 is designed as a multi-purpose theatre.

At the Robinson College are also technicians to assist with the use of the College's comprehensive range of audio visual equipment which includes: video and data projectors, video recorders and 35mm slide projectors, overhead projectors, screens, flip charts, white boards and microphones. Closed circuit TV can also be made available in certain areas. An ISDN line is installed for video-conferencing. There is no additional charge for the use of this equipment.

Broad and accommodation- Robinson College

Full board and accommodation are included in the admission fee. The College cuisine is of a very high standard and has a well-deserved reputation for its quality. Accommodation is provided in single study bedrooms at the Robinson College.

For more information:

www.samco.org/academy

SAMCO NEWSLETTER - ISSUE 10 JULY 2003

Published by VCE

News from the Profession & Practice

On the Dynamic Response of Stay Cables

Introduction

Composite cables have recently widely applied in engineering structures. Due to the complex nature and variable boundary conditions currently available assessment methods fail. Cable supported structures and external pre-stressing is booming, creating a need for innovative test and assessment solutions. The need for monitoring to be applied for maintenance and rehabilitation planning as well as lifetime assessment is realized by the owner of the structures.

Up to today the development of bridge construction has continued, constantly new materials and technologies have been used – the limits of technological feasibility has continuously shifted into the extreme range. Whereas increasingly wide spans have been successfully bridged, numerous structural problems have emerged which have to be considered during planning. The dynamic properties of the respective structure have assumed a special importance in this connection. As early as in the 19th century, after the disaster in the Tay Bay, dynamic load cases were considered important factors during the planning of structures.

In the course of history of bridge construction dynamic loads on bridges were to provide for big surprises frequently. In the 20th century in particular the spectacular collapse of the Tacoma Narrows suspension bridge in the US state of Washington on 7 November 1940 has to be emphasized in this connection, where fortunately no human-being was harmed. The catastrophic collapse of the Tay bridge as well as the spectacular failure of the Tacoma Narrows bridge in the USA in 1940 made the responsible engineers as well as the general public aware of the significance of dynamic effects in the building trade. World-wide the research activities in the field of dynamics were intensified. (Figure 1)

Today the practical and easy availability of dynamic investigation methods has been reached by means of the possibilities of modern measuring and analysis techniques. Not only in the last few decades and centuries were engineers confronted with vibration problems at structures. Also during the last few years, despite sufficient knowledge of dynamic effects as well as the decisive structural parameters, vibration problems have continued to emerge in building, above all in bridge construction. Here above all the "Erasmus-Bridge" in Rotterdam opened to traffic in 1996 as well as the "Millennium Bridge" in London opened on 10 June 2001 have to be mentioned. it is clearly recognizable that there is still extensive demand for research in the field of structural dynamics. Whereas for some problems respective solutions or assessment methods are already existing, there are still numerous fields where practical approaches and investigation methods are lacking.

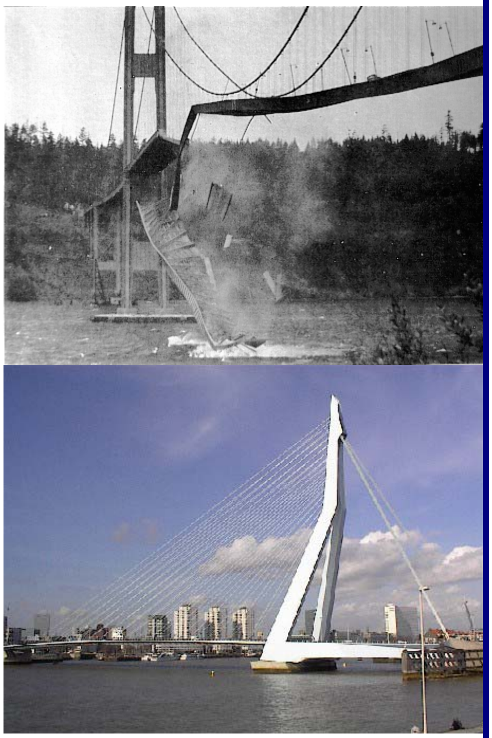

Figure 1. Past and recent vibration problems of cable supported structures

State of the Art

The main objective of the current research activities is the development of accurate, non-destructive methods for the determination of the tensile force effective in the cable on the basis of vibration measurements.

Methods used up to now are either very time-consuming and expensive (for example by lift-off tests with a repeated application of the hydraulic jack) or can cause damages in the cable itself, the anchoring structure or the input area of the cable forces. Principally up to now also vibration measurement methods were used for the determination of the effective cable force, the accuracy achieved in this process was, however, not satisfactory. Above all in case of high cable forces and short cables sometimes errors of up to ± 10% of the actual cable force could be determined. (Figure 2)

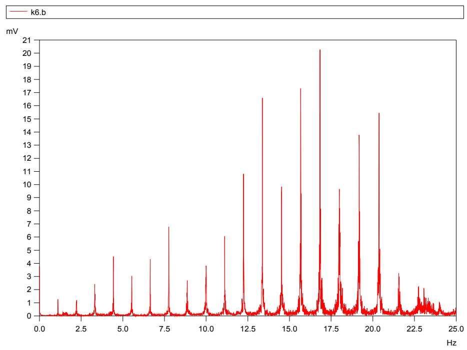

Figure 2. Frequency spectrum obtained for a stay cable

Solution

A very exact and at the same time economical determination of the cable force can be performed by measuring the eigenfrequencies of the fundamental and harmonic modes. The cables are stimulated to vibrate by traffic or other environmental (ambient) sources. The recording of the effective acceleration and a subsequent conversion of the signals into the frequency range by means of a Fast-Fourier-Transformation (FFT) leads to a raw spectrum very quickly. The latter shows the structural response of the cable, with a clear distinction between the fundamental and the harmonic oscillations. As the higher frequencies ideally always represent a multiple of the fundamental frequency, a determination of the cable force is easily possible.

Figure 3 Ambient vibration testing of a stay cable

News from the Profession & Practice

The identified eigenfrequency (f) with the order k is a function of the effective cable force (N), the length (l) of the cable between the nodes of the first mode shape (free vibration length), the mass (m) of the cable per metre and the boundary conditions. Equation (1) shows the simplest form of this coherence without correction parameters, which is fully valid for the ideal taut wire.

$$f_k = \frac{k}{2 \cdot l} \cdot \sqrt{\frac{N}{m}} \qquad (1)$$

Whereas some years ago it was customary to determine the effective cable force exclusively on the basis of the first eigenfrequency, it soon showed that this procedure only brought insufficient – because too inaccurate – results. Satisfactory results were achieved in the last few years by using the two following approaches where the force determination was done on the basis of equation (1) and only eigenfrequencies f were varied as input parameter of the calculation:

- application of $f_2/2$ as input parameter of the calculation, which could clearly improve the accuracy of force determination.
- determination of an arithmetic mean value from the first 5 or 10 identified eigenfrequencies, which are the basis of the force determination. However, the studies in the scope of this work also showed high errors in some cases as the non-linear connection between fundamental and harmonic oscillations exerts a clear influence. In particular in the case of high cable forces errors of the order of ± 5% were determined.

In the scope of this work a practice oriented method was developed which enables the determination of the effective cable force under the consideration of the real bending stiffness of a cable. The accuracy of the force determination is clearly higher than for methods used up to now and therefore fulfils the requirements of engineering. As a real cable, however, deviates from the ideal concept very clearly, an accurate calculation of the cable force is much more complicated. In particular the bending stiffness of the stay cables is significant because it can exert a decisive influence on the eigenfrequency in a high band width. If a complete flexibility of the stay cable (ideal concept of a tight wire) is assumed, the bending stiffness can be theoretically neglected.

If the cable, however, deviates from this ideal concept (this is above all the case for thick and short cables), its bending stiffness is decisive for its behaviour. During the field measurements of stay cables it was realized that a trend towards increasing frequency differences in the high bandwidth is recognizable. Whereas between the first 5-10 eigenfrequencies and their order k there is a linear coherence, the higher eigenfrequencies clearly deviate from this linear (ideal) progress.

The eigenfrequency of a cable is therefore dependent on the cable force and the bending stiffness, the fundamental modes
(≈ f_1-f_5) of a cable being decisively determined by the cable force, the higher mode forms but also by the bending stiffness. The bending stiffness is of secondary importance to the dynamic behaviour due to the minor modal curvature of the fundamental mode during movement. The influence of the stiffness gains importance for a greater modal curvature of the cable in case of higher natural vibration modes.

The application of this method was tested on several stay cables and the results have been compared to the design cable force values as well as to the basic identification method employing a mean value for the frequencies only. From these tests it could be derived, that the accuracy of this solution is close to ± 1% of the acting cable force.

Summary

Problems with vibrating cables are wide spread, and knowledge on the mechanism is only partly available at present. The basic phenomena are well understood, but in practice the vibration is much more complex. The on-going research work should be a help towards achieving better knowledge on the performance of stay cables.

A large number of bridges are reaching the end of their service lives worldwide. In many cases it might be more economical to retrofit them, or only some structural elements like stay cables, instead of completely replacing them. Through the ambient vibration test method the real structural behaviour of the bridge of the specific cable can be determined, and the future planning for the structure can be based upon reliable and accurate structural models. This will increase the reliability and safety of structures.

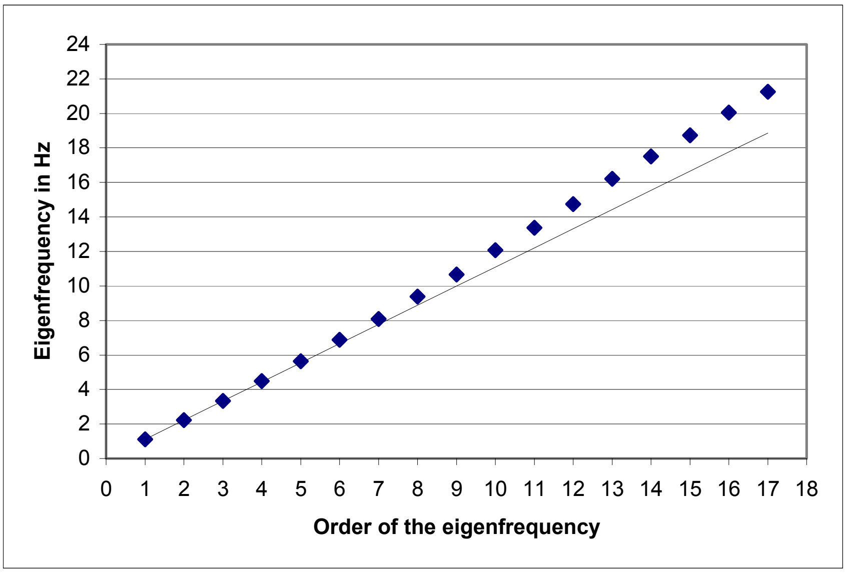

Figure 4 Shift of frequencies of a real cable

Contact

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Company Profile

LMS INTERNATIONAL

Empowering Engineering Innovation

About LMS

LMS is the fastest-growing provider of solutions that integrate functional performance engineering into the digital development pipeline. We provide the testing systems, multidisciplinary virtual prototyping software, engineering services and collaborative engineering tools that enable our customers to turn product refinement and superior process efficiency to their strategic competitive advantage.

Through our technology, software, and people, LMS has become the partner of choice for Fortune 500 companies in the automotive, aerospace, and other advanced manufacturing industries around the world.

The company's strategy has encompassed organic growth through worldwide expansion, new product development and diversification of the application lines - as well as growth through acquisitions of complementary businesses. LMS is certified to ISO9001 quality standards, and employs over 550 people in 16 subsidiaries around the world.

Functional Performance Engineering

While many customers may judge a product by its looks, the engineering of its functional performance and the refinement of 'invisible' features forms an equally important part of the development process. Legislation often dictates the standards for objective attributes such as structural integrity, sound levels and emission levels. And clearly the structure must withstand the forces it encounters in real-life. But how do you derive the dynamic design loads in complex multibody structures such as a suspension unit or engine system? How do you ensure an off-road vehicle will be just as reliable as the mainstream platform it was derived from? How do you guarantee crash and occupant safety while minimizing structural weight?

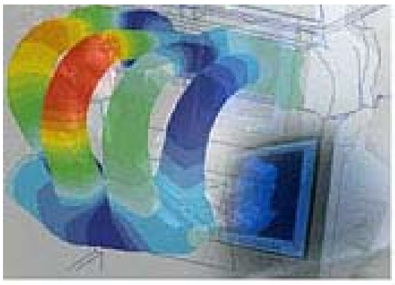
As designs appear very similar, subjective attributes, such as comfort, sound quality and driving satisfaction becoming more and more key product differentiators.

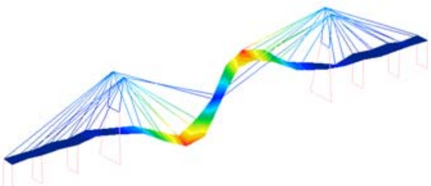
Building in performance and the perception of "quality" changes the focus of the entire engineering process. How can you ensure that a telephone conversion will be 'intelligible' in the presence of background noise? How do you design a suspension for a sporty ride? How can you tune an engine to roar during roar during hard acceleration and be whisper-quiet as it cruises?

Design problems with such 'system level' attributes are traditionally only discovered late in development - when the final prototypes are available and design flexibility has usually been lost. The only resort is to use costly palliative treatments. Products must be more refined. Products must be developed within the ever tighter constraints of time, money, and resources. Products must be "designed-right-first-time". Given the commercial and technical pressures, and the fact that the traditional processes have become a bottleneck, a radical change is not just desirable. It is essential. By combining the 'real-world' with virtual prototyping techniques, our unique hybrid simulation approach enables manufacturers to streamline development processes, save money, improve product quality, and avoid the flawed concept altogether.

Innovating the Functional Engineering Process

Forward-thinking manufacturers talk of radical process breakthroughs and development cycles in terms of months rather than years. They want their people to move to a knowledge-driven collaborative working environment. They want their digital development pipeline to encompass more than the 'form and fit' stages of the design process. And many have chosen LMS as their partner to achieve these changes. No other vendor provides the initiatives, products and services that can help them to transform functional performance engineering from a difficult challenge to a strategic competitive advantage.





As a market leader in physical test we have created many innovative technologies for the refinement of physical prototypes. Over the last few years we have also invested in critical technologies for virtual prototyping, with similar refinement capabilities. We can now envision an engineering process where critical product qualities are designed-in then refined throughout the development process: using upfront analysis at the concept stages, managing refinement and cross-disciplinary product optimization using virtual models, and performing in-depth testing of a reduced number of physical prototypes. Ultimately, it's all about moving away from the expensive - and not always effective - "Test Analyze and Fix" approach, to a new paradigm: "Design-Right-First-Time".

By teaming-up with leading manufacturers from Europe, Japan, and the US, we have developed the technologies and experience to effectively eliminate a number of physical prototyping stages. This is a significant step towards the ultimate dream of building only one physical prototype - namely the final product. Widespread deployment of these novel process-centric solutions will, for example, enable our automotive customers to save millions of dollars for each major car program. Given the competitive, legislative and globalization pressures of today's industrial environment, it's a compelling business case. It's the result of "Empowering Engineering Innovation".

Contact

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Announcements

5th International Symposium on CABLE DYNAMICS

Date:
September 15-18, 2003

Location:
Santa Margherita, Italy

The registration form is now avaloable on line
Visit the Symposium website http://www.conf-aim.skynet.be/cable :
the advance programme with the list of selected papers (technical programme) is available.

Register now and you will be granted the **early bird registration fee** !

Symposium preferred subjects

1. cable modelling
2. methods of non-linear dynamics
3. fluid-structure interactions
4. methods for controlling dynamic response
5. field experience sharing

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Calendar Of Events

JULY 2003

1.-3. Structural faults and repair: extending the life of bridges; *London, UK.*
URL:http://www.structuralfaultsandrepair.com

13.-16. ASCE International Conference On Pipeline Engineering and Construction*; Baltimore, MD*
URL:http://www.asce.org/conferences/pipelines2003/

AUGUST 2003

12.-16.International Civil Engineering Conference on Sustainable Development In The 21st Century, *Nairobi, Kenya*
URL:http://www.insightkenya.com/jkuat/conference.html

27.-29. IABSE Symposium, Structures for High-Speed Railway Transport; *Antwerp, Belgium.*
URL:http://www.iabse.ethz.ch/conferences/Antwerp/Antwerp.html

21.-21. Construction Site Safety and Crane Safety Seminar*; Berkeley, CA*
URL:http://www.constructioninst.org/

22.-23. Mega Projects of the West Coast II; *Berkeley, CA*
URL: http://www.constructioninst.org/

SEPTEMBER 2003

10-15. 3rd International Conference on Debris-Flow Hazards Mitigation *Davos, Switzerland*
URL:http://www.wsl.ch/hazards/3rdDFHM/welcome-en.ehtml

15-18. 5th Symposium on Cable Dynamics; *Santa Margherita, Italy.*
URL: http://www.conf-aim.skynet.be/cable/

22-24. IABSE Symposium Metropolitan Habitats and Infrastructure; *Shanghai, China.*
URL:http://www.iabse.ethz.ch/conferences/Shanghai/PI/Shanghai.html

OCTOBER 2003

5-7. Conference, Council on Tall Buildings and Urban Habitat - Tall Buildings and Transparency; *Stuttgart, Germany.*
URL: http://www.ctbuh-stuttgart.de/

15.-16. The 4th Joint Symposium on Information Technology in Civil Engineering; *Nashville, TN*
URL: http://www.asce.org/conferences/annual03

23.-24. U.S. Universities Council on Geotechnical Engineering Research (USUCGER); *Las Vegas, NV*

NOVEMBER 2003

12-15. Civil Engineering Conference and Exposition 2003*; Nashville, TN*
URL:http://www.asce.org/conferences/annual03

13-15. SHMII-1'2003 Conference - Structural Health Monitoring and Intelligent Infrastructure; *Tokyo, Japan.*
URL: http://www.civil.ibaraki.ac.jp/shmii/

DECEMBER 2003

1.-3. ILCDES 2003 - Integrated Lifetime Engineering of Buildings and Civil Infrastructures; *Kuopio, Finland.*
URL:http://www.ril.fi/Resource.phx/ilcdes2003/index.htx

8-9. ACI Conference - Seismic Bridge Design and Retrofit; *La Jolla, CA, USA.*
URL:http://www.concrete.org/EVENTS/conferences/conference.htm

Imprint

SAMCO News

SAMCO News is a digital newsletter accompanying the SAMCO Network. It is funded by the European Commission in the frame of the GROWTH project SAMCO CTG2-2000-33069. It is an information and communication platform for the participants of SAMCO. It is issued periodically every second month.

SAMCO News is available at http://www.samco.org/news

Funding

The SAMCO Network is funded by the European Commission (http://europa.eu.int) within the *"Fifth European Framework Programme",FP5,* (http://www.cordis.lu/fp5) which covers Research, Technological Development (RTD) and Demonstration activities. FP5 has a multi-theme structure, consisting of Specific Programmes. These Specific Programmes are further divided into Horizontal Programmes and Thematic Programmes. One of these Thematic Programmes is the *"Competitive and Sustainable Growth"* Programme (http://www.cordis.lu/growth/) under which SAMCO is running.

SAMCO is running under the exact term: CTG2-2000-33069
Shared-cost RTD and Demonstration project, Concerted Action/Thematic Network
Duration: 48 months

Publisher

VCE

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