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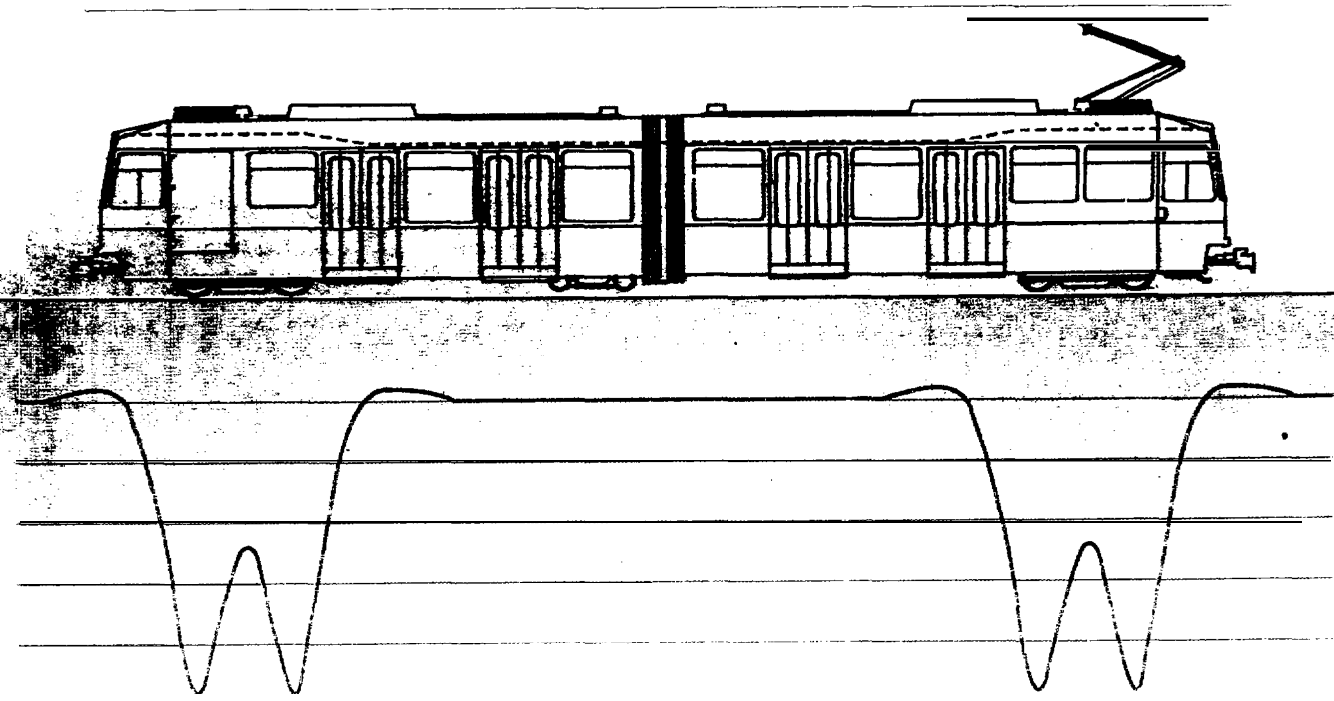
Project BE-4(I86 **Contract BREU-564**

'Development of advanced prefabricated urban slab track systems by application of innovating design methodologies for improving overall system performances taking into account environmental factors.

Synthesis Report



Synthesis Report

PROJECT BE-4086 CONTRACT **BREU-CT91-0564**

DEVELOPMENT OF ADVANCED PREFABRICATED URBAN SLAB TRACK SYSTEMS BY APPLICATION OF INNOVATING DESIGN METHODOLOGIES FOR IMPROVING OVERALL SYSTEM PERFORMANCES TAKING INTO ACCOUNT ENVIRONMENTAL FACTORS

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AUTHORS

Inprevib S.p.A.

Str. Galileo Ferraris, *127*
10134 Chivasso (TO) - Italy
tel. +39 119113888
fax +39 119102348

Postelectrica S.A.

Svda. Modesto Lafuente, 15
34002 Palencia - Spain

FEVE

General Rodrigo, 6 -3a
28003 Madrid - Spain

ABSTRACT

The development of advanced urban track systems providing enhanced performance particularly in terms of ground-borne vibrations reduction and railway noise control. The present project, performed with the support of the European Commission Brite - Euram Programme, is aimed to the improvement of ballastless massive tracks with large floating masses supported by elastomeric layers, that represent the optimal technical solution to the problem of environmental impact of rail transport systems.

1. INTRODUCTION

The purpose of the project is the development of an advanced urban track system using new design methods which will provide enhanced performance particularly with a view to environmental impact. The advanced urban track system shall represent the optimal technical solution to the problem of environmental impact of rail transport systems.

To satisfy this purpose, among the possible different technical solutions, that which has been pursued is based on the improvement of ballastless massive tracks with large floating masses supported by elastomeric layers.

This improvement is consisted in optimizing the technical measures which can reduce the ground-borne vibrations caused by rail systems and in defining innovative measures for railway noise control.

Besides, the basic ballastless track system has been modified and upgraded to meet conventional design criteria, performance standards and particular requirements of way characteristics (viaduct, tunnel, embankment), alignment (curvature, cant) and line classification (axle load, tonnages and maximum speed).

Other important aims which have been considered in the research project are the improvement of the reliability, availability, durability and maintainability of the track system and the enhancement of the quality of track construction through the use of prefabricated concrete products.

Finally, the new system has been designed in order to be usable in a wide context, i.e. in different countries taking into consideration their specific needs and technical traditions, and also for different line classifications.

2. TECHNICAL DESCRIPTION

The defined objectives have been achieved through an integrated use of different means, according to a scientific applied research approach which has been mainly based on execution' of experimental activities, development of new specialised software and numerical computations construction of prototypes and study of advanced materials.

In detail the main means used to achieve the objectives of the research project are the following:

- collection, selection and examination of scientific publications, standards and supply specifications
- structural/dynamic numerical analyses and numerical simulations of noise emission and propagation
- research and development of innovative materials and products (expanded polyurethane and expanded closed cell rubbers) and special solutions to reduce acoustic reverberation (light - weight expanded concrete, draining asphalt and reactive silencers)
- study, design and realisation of specimens for laboratory and field tests and related experimental investigations
- verification and updating of the mathematical models on the basis of the results provided by

laboratory and field tests.

The research work has been developed through the following four main tasks:

Task 1 Performance specification

The performances which the innovating track systems have to warrant have been specified in detail in order to focus the actual detailed aims of the subsequent phases of the project. The main aspects that have been examined are those related to the reduction of induced ground vibrations and containment of acoustic noise. Standards from different European countries have been analysed in order to provide a system utilizable in a wide context.

Task 2 Design methodologies

The need of developing advanced systems capable of taking into account the several physical phenomena involved the study, has required the application of innovative design solutions and new concepts, therefore requiring to carry out different accurate numerical analyses.

Calculation approaches based on FE (Finite Elements) analyses have been applied for mechanical - structural aspects; moreover acoustic architecture interventions on the slab in order to contain noise effects have been studied using BE (Boundary Elements) methods.

Designing of specimens for lab and field tests have been performed, and procedures to be carried out for lab tests and field tests have been defined.

Integrated design procedures in order to treat the different aspects involved in the project (structural, acoustic and vibrational aspects) have been defined introducing an innovative concept in the prefabricated concrete products design field.

Task 3 Specimens construction

In accordance with specimens specifications provided by task 2, several specimens have been manufactured, and then tested in the course of the subsequent task 4. Specimens for lab tests and for on line surveys have been made; the first have been designed in order to reproduce, not necessarily at the same time, the different specific technical aspects of interest, and have been realised taking into account the performances of the experimental rigs which have been used for carrying out the tests.

Specimens for on line tests have been made with the purpose to lay down trial railway lines for a total length of 200 m. More precisely, 100 meters of prototype track have been built and laid in Italy on FS's railway lines, while 100 meters have been built and laid in Spain on FEVE's lines.

Task 4 Experimental tests

In accordance with test procedures specification, lab and on line experimental tests have been carried out. By means of an intensive feed back of experimental results provided by the tests with the numerical outcomes obtained by the design approach (task 2), the proposed different track system solutions have been iteratively optimised.

At first experimental lab tests have been performed. Subsequently on line experimental tests have been carried out with the purpose of a final verification of the optimal solutions showed by the previous iterative phase between numerical predictions and experimental data obtained in lab.

3. RESULTS

The work has been focused on the behaviour improvement of ballastless massive tracks with large floating masses supported by elastomeric layers, that has been confirmed to represent the optimal technical solution to the problem of environmental impact of rail transport system.

This is resulted both in the identification of suitable technical and technological solutions (use of innovative materials and definition of special architectural configurations according to new design concepts) and in the definition and validation of specific numerical approaches based on FE analyses for mechanical - structural aspects and on BE methods for acoustic architecture interventions.

The main results achieved are the following:

- detailed identification of reference performance specification that the new advanced track system must meet and definition of design criteria to be used to tailor the final product to the specific conditions that correspond to the different line classifications in order to enable the use of the advanced track system in a wide context, i, e. in different countries taking into consideration their specific needs and technical traditions

- development and validation of special analytical procedures and related new advanced finite elements models to handle mechanical - structural aspects, i.e. soil - track structure - rail interaction problems and vehicle dynamic behaviour; moreover, definition and set - up of numerical simulation procedures for noise emission and propagation using available finite elements - boundary elements numerical codes to contain noise effects

- development of innovative materials and products required to assure the envisaged performances to the advanced slab track systems; in particular innovative elastomeric mats (expanded polyurethane and expanded closed cell rubbers) and special solutions to reduce acoustic reverberation (light - weight expanded concrete, draining asphalt, reactive silencers and special acoustic architectural interventions regarding the slab upper surface configuration)
- detailed design, construction and testing of performances of a new advanced floating - mass slab track system considering different final configurations mainly related to different line classifications (track gauge sizes and axle - load) and technical solutions to contain noise emission
- improvement of the reliability, availability, durabilit y and maintainability of the track system and enhancement of the quality of track construction through the use of prefabricated concrete products.

The advanced track systems that have been subjected to final on - line investigations have shown a global acoustic and vibrational behaviour which has to be considered as good for the following reasons:

- the displacement time histories for the rails (connected with wearing of the running surfaces and transit safety) have shown maximum values within the defined range of allowable values
- acceleration levels and spectra in the carriage (connected with passenger comfort and vehicle exposure to dynamic loads) are resulted “just noticeable” according to the ride index evaluation method
- acceleration levels and spectra in the surrounding soil (connected with environmental impact in terms of vibrations emission- and structure-borne noise) have shown a significant reduction of the transmitted vibrations of the order of 25 dB respect to the levels on the rails. This performance can be easily improved through a parametric analysis based on the use of the integrated design procedure set - up in the project
- the vibration reduction, respect to the ballasted reference track, is particularly significant in the frequency range over 60 Hz, where the structure-borne noise is generated
- the acoustic gap usually existing between light weight flat surface slab track systems and ballasted tracks, has been almost fully eliminated through the combined use of massive slabs and specific architectural acoustic measures.

4. CONCLUSIONS

The whole project can be evaluated as successful, especially for the obtained results and for the fruitful collaboration between engineers and researchers from several organisations and laboratories working in different countries of the European Community.

The issue of reducing environmental impact of railways, especially for urban collective rail transport systems, is extremely important from the point of view of the economical and social consequences of vibrational and acoustic annoyance. At the same time it is very complex because of the required expertise involving several disciplines: geotechnical, dynamic, acoustical, mechanical engineering, rubber and civil construction technology and numerical modelling.

Several very successful developments have been achieved in the project. The most noticeable are:

- identification of reference performance specification for the new advanced track system
- development and validation of special analytical procedures and related new advanced finite elements models and definition and set - up of numerical simulation procedures for noise emission and propagation
- development of innovative materials and products required to assure the envisaged performances to the advanced slab track systems (elastomeric mats and special solutions to reduce acoustic reverberation)
- design, construction and testing of performances of a new advanced floating - mass slab track system
- improvement of the reliability, availability, durability and maintainability of the track system and enhancement of the quality of track construction.

The results achieved in the research project represent an effective enhancement with respect to the existing solutions, nevertheless the developed systems still might be improved as far as the containment of acoustic and vibrational disturbance in urban environment is concerned.

In particular the following key points should definitely deserve more attention and research work:

- the vertical stiffness of the system is resulted in general higher respect to the values which corresponds to the optimum compromise between the need both to reduce the vibrations transmitted to the base-slab and to limit the deflection of the rail. In other terms the system has shown a good performance in terms of deflections, but its vibrational behaviour could still be improved. This problem can be solved enhancing the production process of the resilient mats which could be based on the use of open cells products and/or through the introduction in the production pro-of a stabilisation phase before to lay down the material

- the acoustic performance of the developed technical solutions to contain noise emission, can be positively evaluated having shown their capability to reduce the existing acoustic gap between ballasted tracks and flat - surface ballastless systems. Nevertheless, these positive results might be furtherly improved through studies starting from the know - how acquired in the course of the project regarding to acoustic architectural configurations, innovative materials and numerical modelling.