Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Dott. Ing. Mario Romani

Ufficio Calcoli Strutturali
Direzione Ricerca e Progettazione
ANSALDOBREDA S.p.A.
Contents

• Introduction
• Tram model
• Linear analyses
• Non linear analyses
• Works in progress
• Conclusions
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Ufficio Calcoli Strutturali
Direzione Sistema Veicolo (Pistoia)

• 6 Persons

Competencies
• Static analysis (linear and non linear)
• Fatigue analysis
• Dynamic analysis
• Running behaviour / Comfort
• Crash analysis
Introduction

• Main features of SIRIO tram:
  – Completely low floor tram, with pavement height at 350mm over the top of rail,
  – Architectural modularity,
  – Bogies having independent wheels.

• Purpose of analyses:
  – Simulation of SIRIO tram with SIMPACK.

• The activities on this project are not finished yet
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Tram model

In order to reuse the sub components of tram SIRIO for Milan in other projects the database concept of SIMPACK is very useful

Mario Romani, ANSALDOBREDA S.p.A.
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Model of Tram SIRIO for Milan

Motor Bogie
Trailer Bogie
Joint allowing only yaw
Joint allowing yaw and pitch

Model of Tram SIRIO for Naples
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

• Trailer bogie drawing

Independent wheels

Low floor concept
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

- Motor bogie drawing
  - Mechanical differential with locking couple
  - Low floor concept
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Independent wheels topology

Motor bogie wheelsets

- A) Independent wheels
- B) Connected wheels
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Trailer bogie model

- Stiffness of primary and secondary suspension stage
  - Dampers characteristics
- Bumpers behaviour
- Rubber joints stiffness
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

- Non linear bumpers behaviour
- Non linear dampers characteristics
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Motor bogie model

• Stiffness of primary and secondary suspension stage
  • Dampers characteristics
• Bumpers behaviour
• Rubber joints stiffness
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Wheel Rail Profiles

- Rail profile: lR UNI3142
- Wheel profile: UNI3332

Wheel Rail Global Values
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

• Layout of tram SIRIO for Milan

Dampers between coaches
Model of tram SIRIO for Milan
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Linear analyses

Instability analyses

- Modal analysis
- Parameter variation
- Transient phenomena

First mode: Roll mode is not influenced by speed

Second mode: Yaw mode for the front coach and the first motor bogie

Third mode: Yaw mode for the rear coach and the last motor bogie
Modal analysis

First mode:
Roll mode

Second mode:
Yaw mode for the front coach and for the first bogie plus roll mode

Third mode:
Yaw mode for the rear coach and for the last bogie plus roll mode
Parameter variations

• The damping of the longitudinal damper doesn’t change the critical speed

• The damping of the dampers between coaches has a big influence for the critical speed
Transient phenomena

The tram is running over a straight and perfect track; but it is introduced one initial condition in order to study the transient phenomena due to it.

Frequency related to the second mode
Non linear analysis

Time integration analysis of the runs of the tram over some curved and irregular tracks

The analysis of WR forces is done with a Matlab elaboration, which reads the file created with the graphical 2D post processing
Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

Post processing of the WR forces

![Graph showing force distribution](image)
Works in progress

• Adding into the simulation the model of mechanical differential with locking couple
• Study of tram behaviour in case of worn WR profiles
• Comparison between calculation and test results
Conclusions

• SIMPACK is very useful for the design of rail vehicles

• The parameter variations module is a power method to explore the design configuration.

• The time integration module is fast