

# Multi-Hertzian Method for simulating Conformal Wheel-Rail Pairs - Application to S1002/UIC60 Pair - Proposal of a Physical Laboratory Test for assessing the Method

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## 1 INTRODUCTION

In 2007, the MMU Contact Benchmark required to calculate the equilibrium of a wheelset using a conformal Wheel-Rail pair (S1002/UIC60) when constrained to lateral displacements of its CoG exceeding the clearance inside a fixed track. Then it happens that, laterally displacing the CoG further some distance without adding external torque, results in lifting opposite wheel and induces large wheelset roll angle. Calculating this roll equilibrium necessitates to develop accurate contact solutions for this conformal pair. Not many such methods have been validated yet and most of the benchmark solutions were adding an external torque in order to maintain both wheels in contact [1].

However, this roll equilibrium beyond wheel lifting is worth being further studied for three reasons:

- This wheel-rail pair, S1002 profile and UIC60 rail canted at 1/40, is largely used in practice
- This situation of lifting opposite wheel currently occurs during dynamical impacts
- A physical model of this case is easy to build and simple measurements of roll angle versus lateral displacement would allow evaluating the overall accuracy of calculations.

Present paper uses the multi-Hertzian method to solve the conformal problem and gives numerical solutions to the MMU benchmark: roll angles and lateral force as functions of constrained lateral displacements. Such results could be assessed using simple correlative lab tests. Unfortunately such tests could not yet be realized at full scale.

This paper proposes an arrangement to make this verification on a scaled model of the wheelset (1/3 rd) which could be produced in the frame of a student work. Full scale results could be deduced according to scaling laws applicable to such contact cases (unchanging contact pressure).

## 2 MULTI-HERTZIAN METHOD FOR CONFORMAL CASES

A “true conformal contact case” would mean two bodies having exactly same and opposite surface curvatures extending largely, such as in a rotating joint. Due to wear mechanisms, this theoretical conformal situation does not exist in practice between wheels and rails. Wheel and rail surfaces which are said “conformal” present in reality small waves inducing modulations and maxima of contact pressure along the overall contact patch. This is the case for S1002 and UIC60 at 1/40. Present method pretends to simulate such conformal situations by assuming that the pressure distribution around maxima can be calculated using Hertz analytical formula.

This method has been practically developed by programming a FORTRAN code named OCREC (Online Calculation of Railway Elastic Contacts). It uses the “gutter concept” [2] which determine areas where it is impossible to find pressure maxima and thus where it is not necessary to look for them.

OCREC code has been developed in the frame of the Hertz theory of elasticity for elliptical contacts and Kalker’s theory for rolling contact with friction. The code allows non-elliptical contact patches to be modeled as a sum of elliptical ones. The properties of the contact patch are calculated online during a dynamic simulation (as opposed to referring to a pre-processed look-up table). At each time step, taking into account their relative situation, a search for all possible locations of maxima of pressure is undertaken across wheel and rail profiles, and then a calculation of the eventual negative normal distance between the un-deformed profiles (maximum interpenetration) at these locations is performed and used to calculate all elastic normal forces.

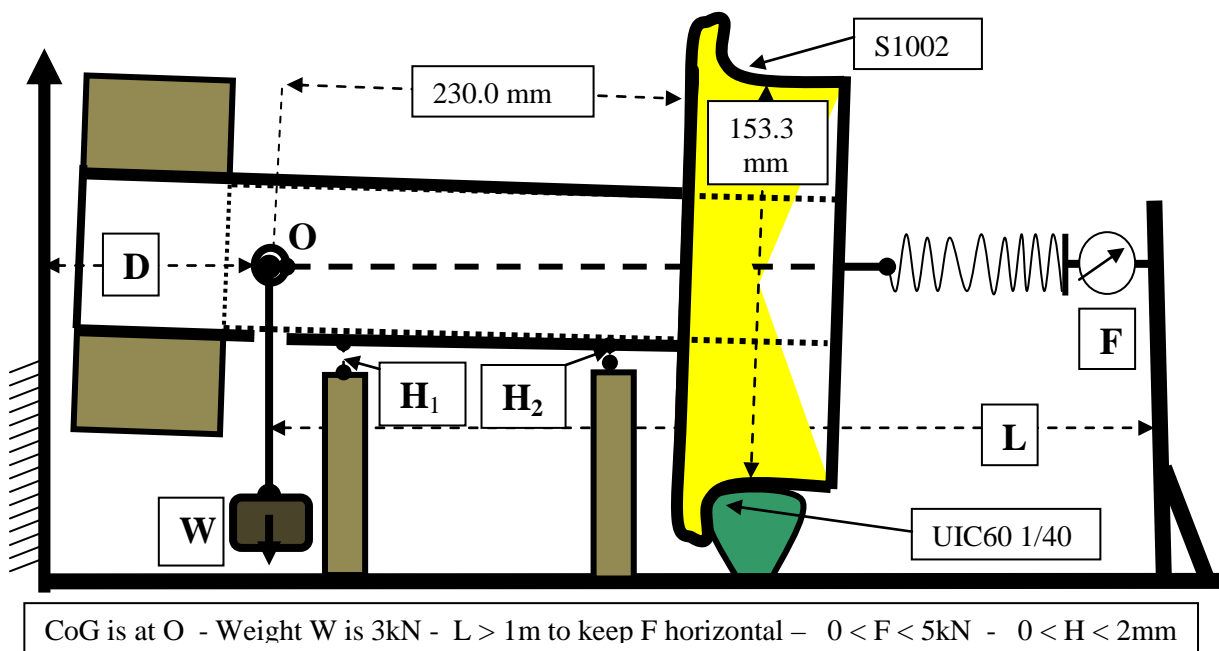
### 3 PHYSICAL TEST MODEL

The figure below is a sketch of the experimental apparatus where only one wheel is machined and fastened to a rigid tube bearing an additional mass in order to fix the CoG at O where a smaller tube crossing the big one is used to attach horizontal force F and vertical force W.

H1 and H2 are measuring the roll angle and D stands for the lateral displacement. Contact surfaces are oiled in order to minimize friction.

Distance L should be large enough in order that vertical component of F could be neglected.

Accuracy of profiles machining should be better than 0.01mm and the rail should be rigidly fixed.



### 4 REFERENCES

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