# 8. Summary & Conclusions

The wheel/rail contact impact forces that occur in the vicinity of the end post at the insulated rail joints (IRJs) has been examined and reported in this thesis. The Finite Element Method and strain gauged experiments have been used in the examination.

The 3D wheel/rail contact-impact FE model employed a two-stage analysis strategy in which the wheel-IRJ railhead contact was first established in the static analysis and the results transferred to dynamic analysis for impact simulations. This strategy was proven efficient to obtain a fast and efficient solution of a steady state rolling contact prior to the impact. The explicit FE method was employed in the dynamic analysis. The master/slave contact surface method was adopted for both the static and the dynamic analyses. To achieve a reasonable model size which is acceptable to the available computing facility, several idealisation and simplification strategies have been employed in following aspects:

- IRJ assembly and wheel profile
- material modelling
- boundary conditions

Some special attention was also paid to the following FE modelling strategies:

- loading
- contact modelling
- meshing

The wheel/rail contact-impact in the vicinity of the end post was exhibited via numerical examples from the FE modelling. The wheel/rail contact impact mechanism was investigated and reported. The associated results of wheel/rail contact were also compared with the HCT. Through a series of sensitivity studies of several IRJ design parameters, it was shown that the IRJ performance can be largely improved with optimised design parameters.

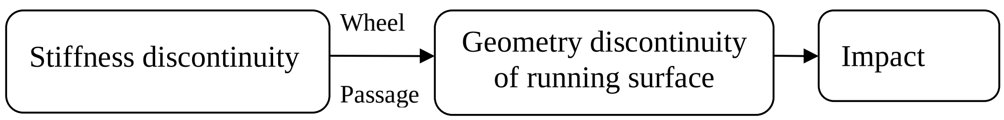
The strain gauged lab and field experiments were reported. The data collected from both tests were processed and compared to the numerical results. The signature of the strain data from the field test was discussed. Both the static and the dynamic FE models were validated using the experimental data. In the lab test, the IRJ was simply supported and subjected to a static load and investigated with several different loading positions along the length of the IRJ. Two traffic conditions in the field test, namely loaded and unloaded coal wagon traffic, were selected to validate the dynamic analysis. Reasonable agreements between the FEA and tests have been achieved.

## 8.1. Conclusions

From the FEA and experiments as reported above, there are several general conclusions obtained as stated in the following part. The specific conclusions can be drawn from the numerical examples and the corresponding experimental data.

### 8.1.1. General conclusions

(1) The wheel/rail contact impact mechanism can be explained through the stiffness discontinuity of the IRJ structure causes a running surface geometry discontinuity during the wheel passages which then causes the impact in the vicinity of the end post.




(2) At impact, the peak contact pressure reduces due to an apparent increase in contact area. In spite of the reduction in peak contact pressure, the maximum Von-Mises stress at impact is larger relative to the pre and post impact stages. Discontinuity of rail in the vicinity of the end post appears to be the primary factor influencing the large increase in Von-Mises stresses.

(3) At the impact, the wheel contacts both rails across the end post.

(4) This 3D wheel/rail contact impact FE model appropriately predicts the wheel/rail contact impact at the IRJs. It is also suitable to be used to conduct the sensitivity study of the design parameters and further improve the design.

(5) The sensitivity study has shown that the impact forces have generally been reduced when any one of the following design parameters are adopted:

- Gluing the end post
- Reducing the gap size
- Adopting flexible support system
- Using end post material with mechanical properties closer to those of steel
- Suspending IRJs between sleepers

The numerical example showed that when all these options employed, the impact factor (between a new IRJ and a new wheel) was reduced to a negligible level.

(6) The static analysis has shown that the elastic model agree well with the HCT in terms of the contact area dimensions and contact pressure distribution. The HCT has been found to be not valid at impact due to the edge effect.

(7) The mesh size influences the contact results significantly. Accurate results of the contact area dimensions and contact pressure distribution require fairly refined mesh within the contact zone. However, the global-scale result such as contact force is not so sensitive to the mesh size within the contact zone.

### 8.1.2. Specific conclusions

(1) The comparison between two available contact constraint enforcement methods in ABAQUS/Explicit, namely, Penalty method and Kinematic method, shows that the Penalty method is more stable numerically.

(2) Under 150KN vertical wheel load and 120Km/h longitudinal velocity, the impact

factor of 1.16 was generated between a new wheel and a new IRJ.

(3) The stress contour showed that the maximum stress was located at 3mm~4mm beneath the contact surface of the railhead. The 150KN wheel load caused fairly localised material plasticity in the wheel/rail contact zone.

(4) The pure sliding motion of a wheel (wheel under braking) generates higher impact load than the pure rolling wheel motion by 13% in the example. This finding indicates the braked case is more likely to cause railhead damage in the vicinity of an end post.

(5) The experiment data analysis indicates that the positions on the railweb of an IRJ in the vicinity of the end post are suitable for dynamic load response capture using strain gauges.

## 8.2. Recommendations

There are several recommendations listed as follows which could further improve the study on the wheel/rail contact impact at IRJs:

(1) To exactly measure the contact impact forces, only expensive systems such as the fully instrumented wheelsets are practically used at this stage. The strain gauged experiments reported in this thesis could be further developed to an inexpensive wayside monitoring technique that determines the contact-impact forces inversely through strain signatures.

(2) The mesh used in the dynamic analysis could be further refined with a higher performance computing facility to obtain more accurate results for the contact associated parameters (such as the contact area, contact pressure distribution etc.)

(3) The permanent deformation or damage on the railhead aggravates the contact-impact force, generating a vicious circle accelerating the overall failure of IRJs. Progressive wheel loads could be applied to the model to investigate the long term impact growth under this scenario.

(4) Although efficient meshing strategy is developed in this thesis, the computational cost is still considerably high, which limits the model for further development. Comparing with the Lagrangian formulation, the ALE formulation maybe more efficient for rolling contact problems. The ALE configuration, despite its rare application for commercial FE codes, may be considered as an alternative option in the future.