Winter‘18 Report
Rail Road Vehicle Dynamics

Under the supervision of Prof. N.S. Vyas

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Contents

About SIMPACK

Simpack is a general purpose Multibody Simulation (MBS) software used for the dynamic analysis of any mechanical or mechatronic system. It enables engineers to generate and solve virtual 3D models in order to predict and visualize motion, coupling forces and stresses.

Simpack is used primarily within the automotive, engine, HiL/SiL, power transmission, railway, and wind energy industrial sectors, but can be applied to any branch of mechanical engineering.

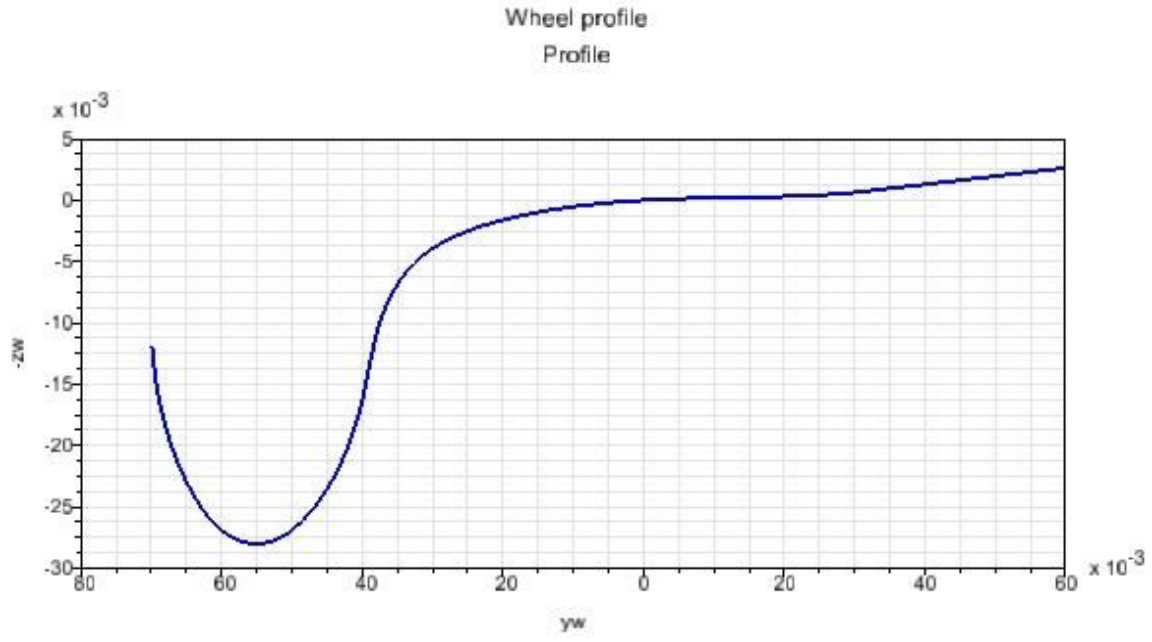
SIMPACK is used for the analysis and design of any type of rail-based vehicle or mechanism–from roller coasters, material handling systems or tramcars to complete articulated high-speed trains. Used worldwide by manufacturers and operators, SIMPACK is the leading MBS software for railway system dynamics.

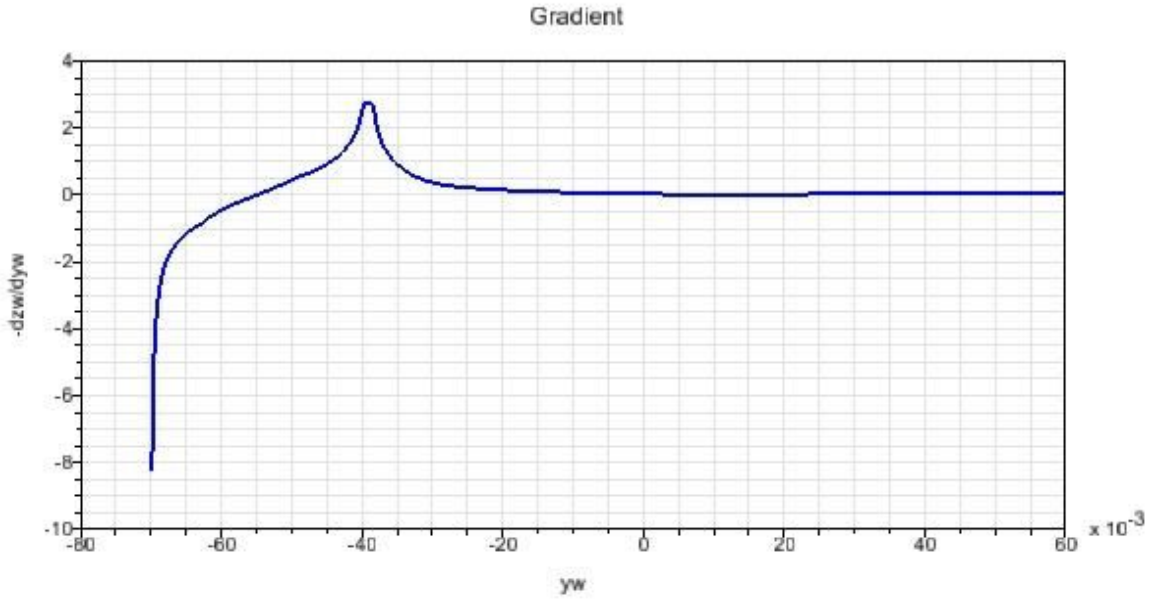
In Railway model, a wheelset could be directly imported with rail and wheel profiles and contact models are also available for the same.

Plots for the wheelset

(Folder: RRVD_Report\Winter Project\RAJESH\Wheelset\Plots)

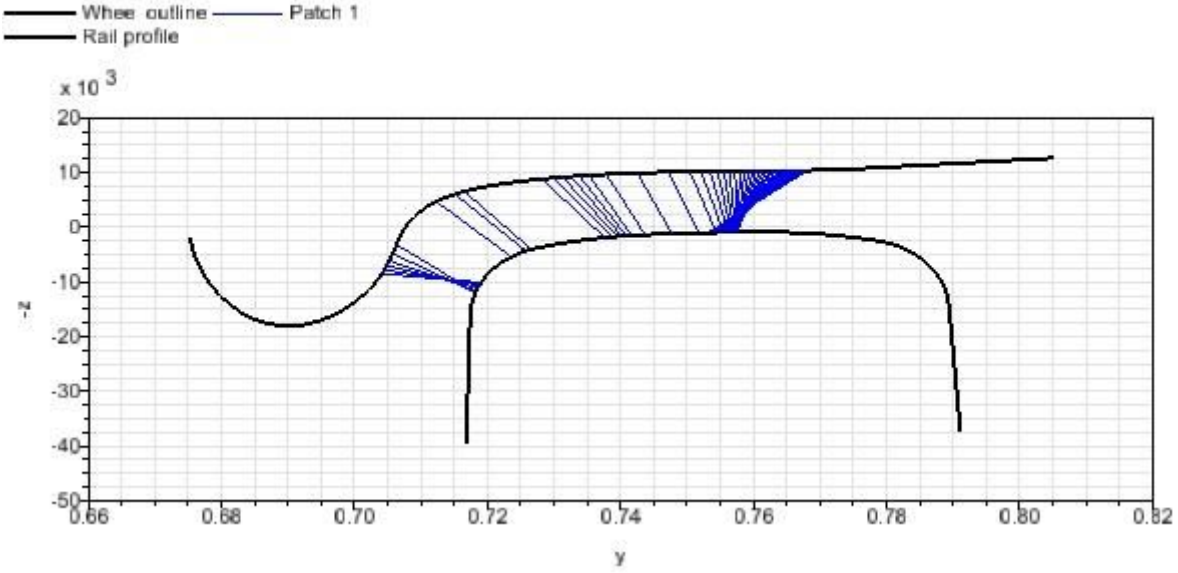
A general wheelset model was available on SIMPACK and the plots which are shown in the next few pages were available with the model.



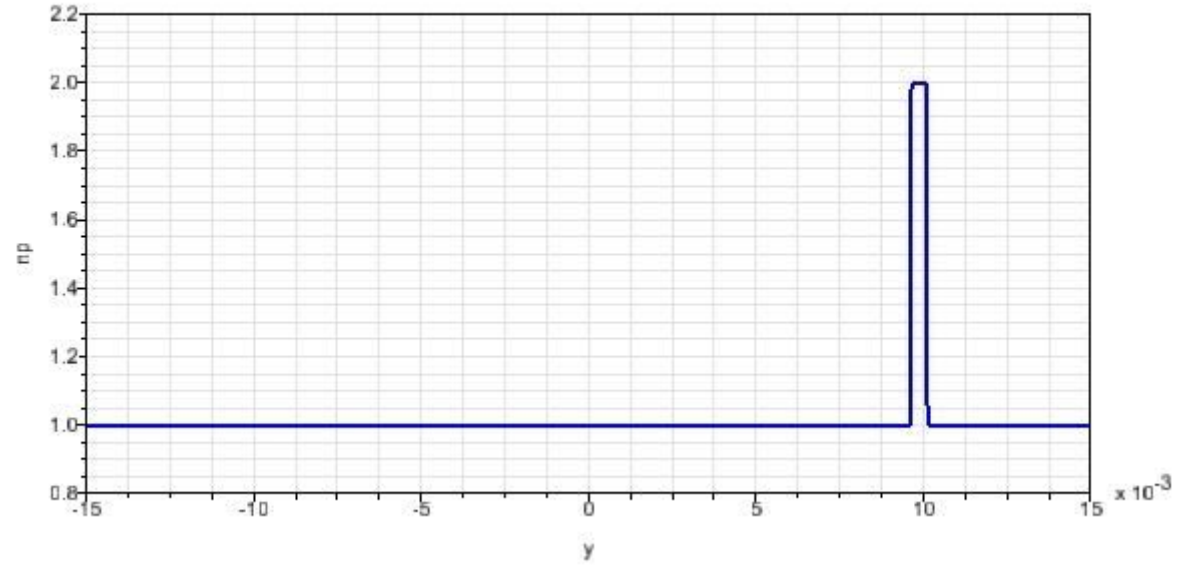


Contact overview

Contact connection lines

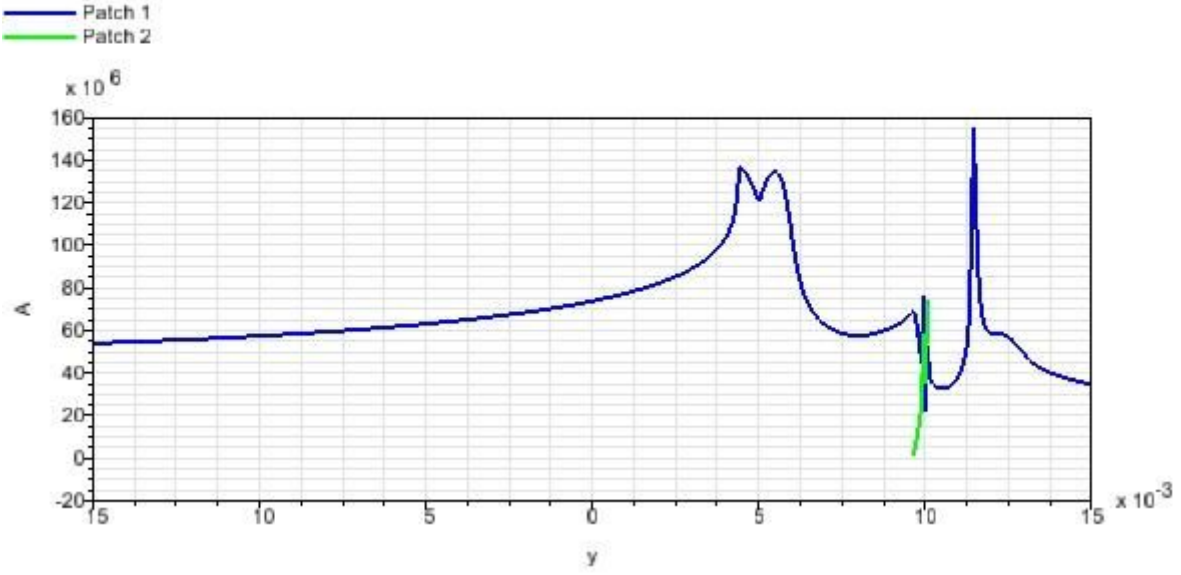


Number of contact patches

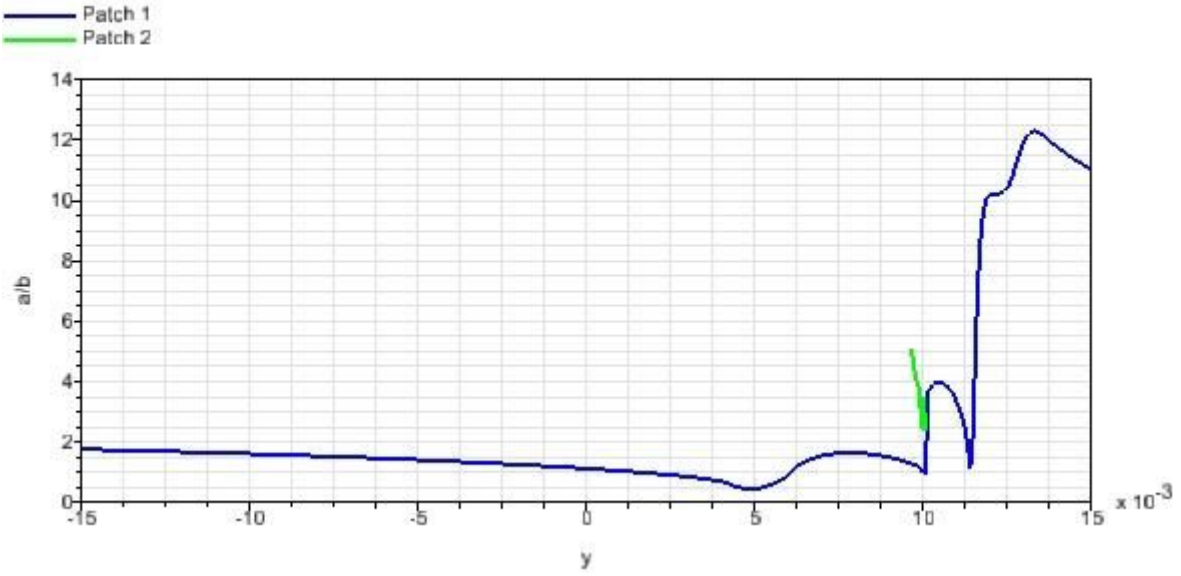


Contact patch dimensions

Contact patch area

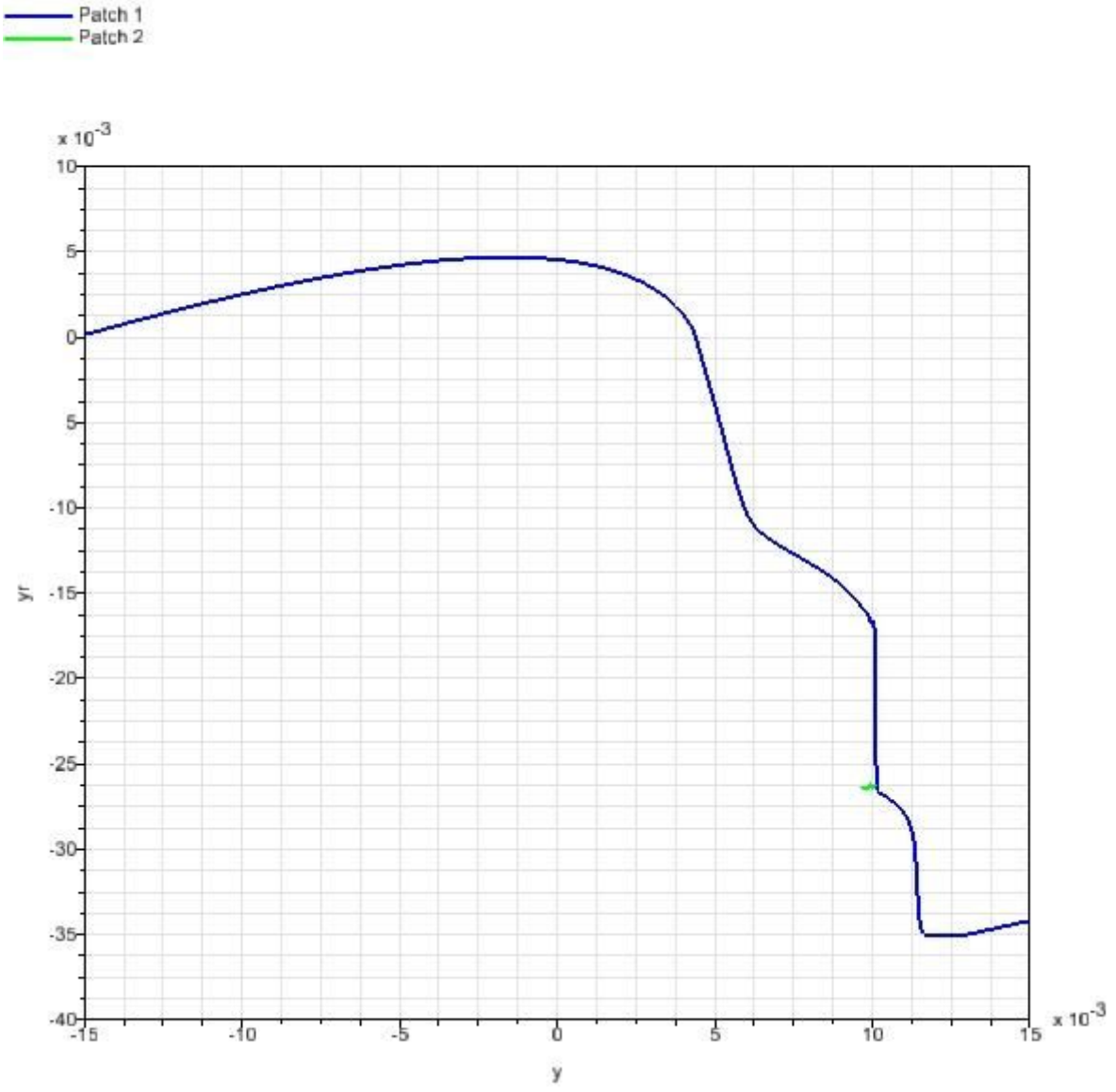


Equiv. semi-axis ratio



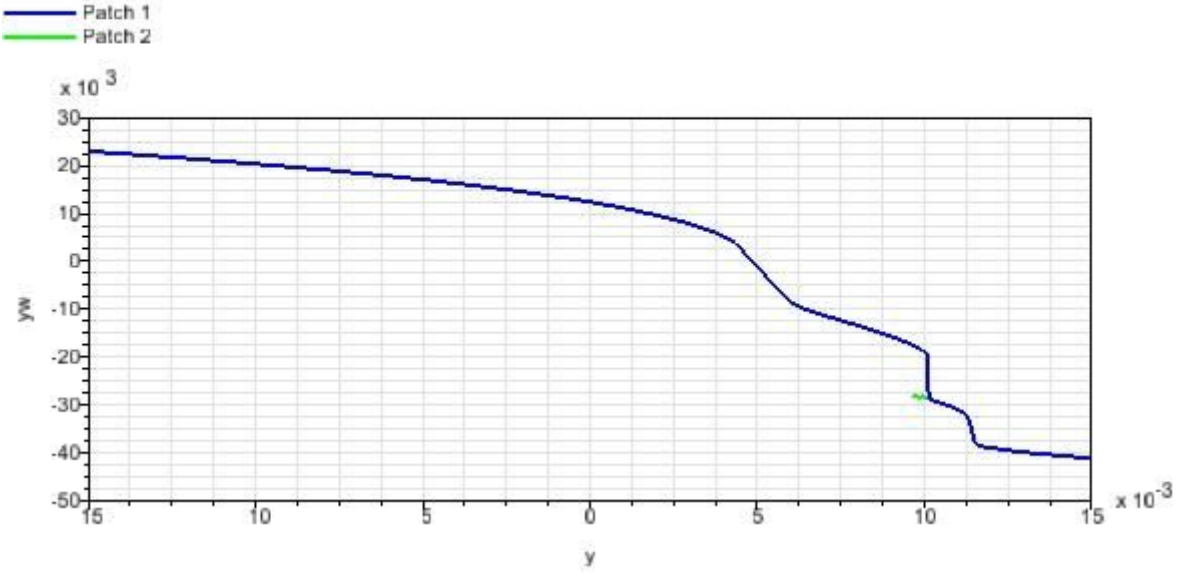
Contact position on rail

Lateral position

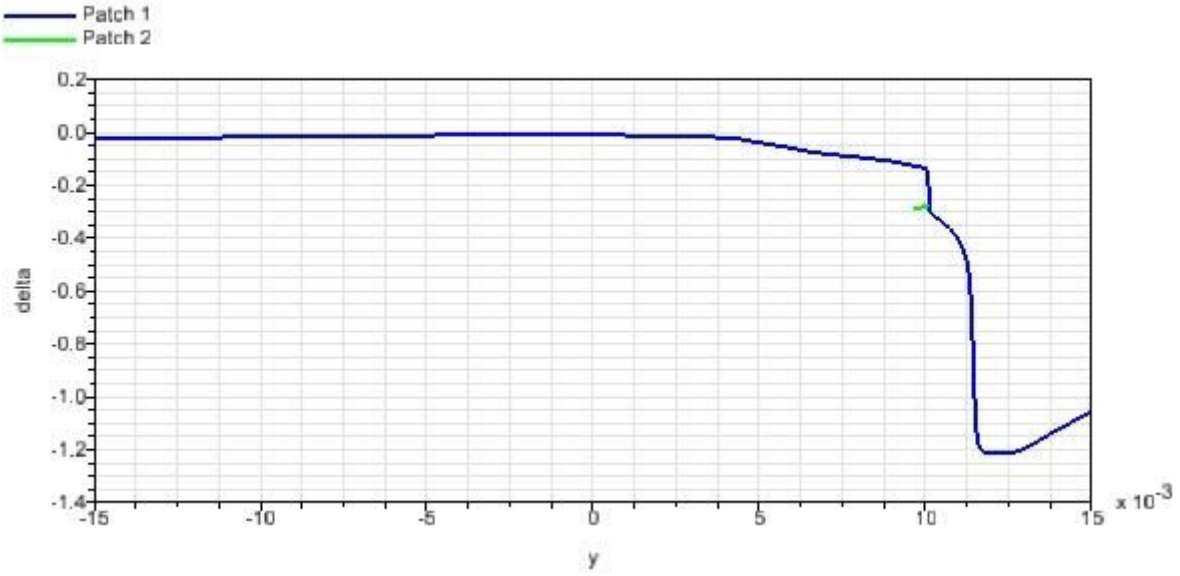


Contact position on wheel

Lateral position

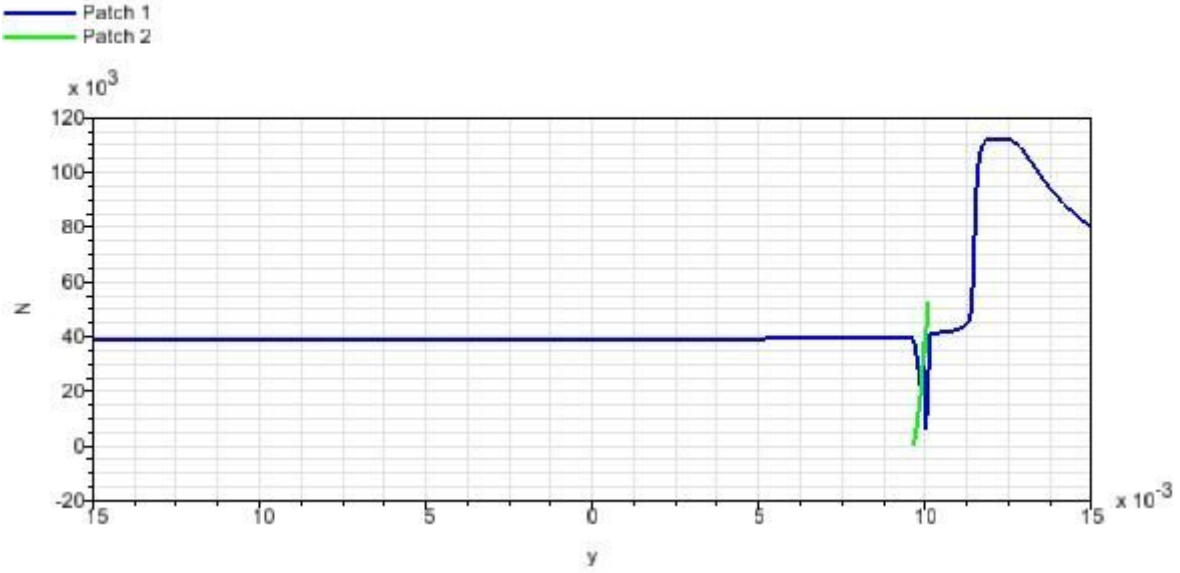


Contact angle

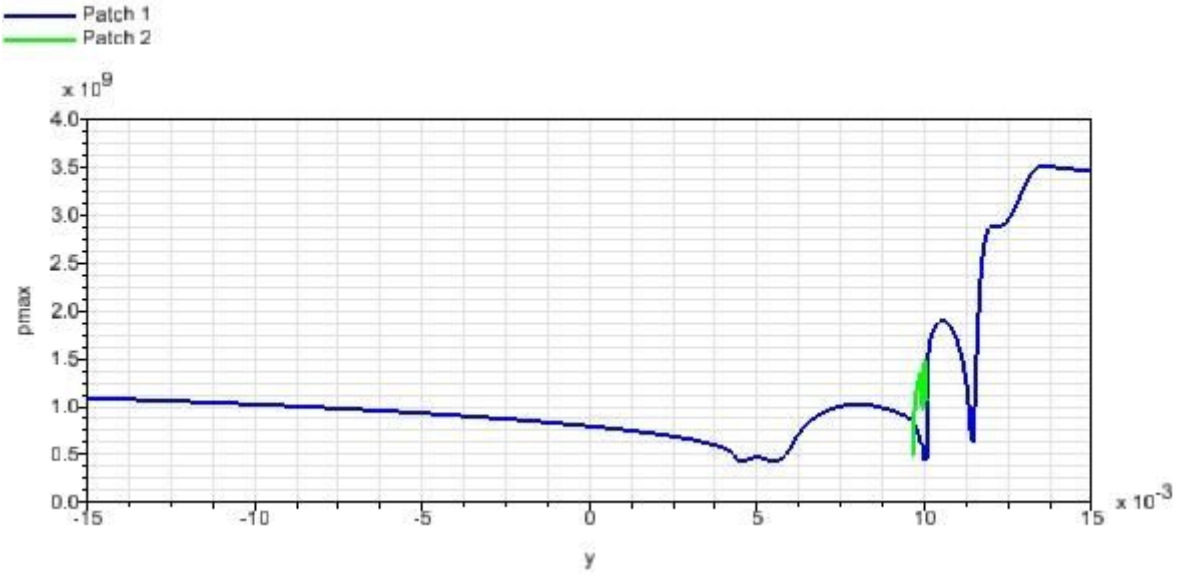


Normal contact

Normal force



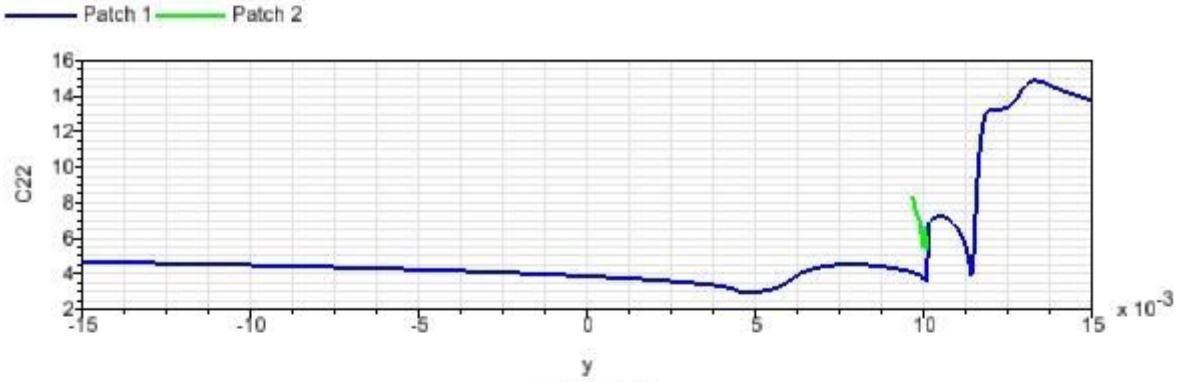
Max. Hertzian pressure



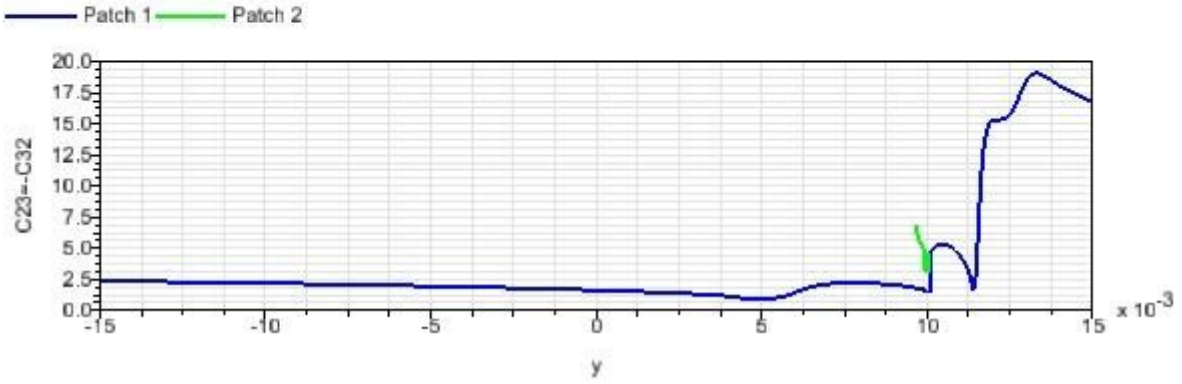
Kalker coefficients

C11

C22

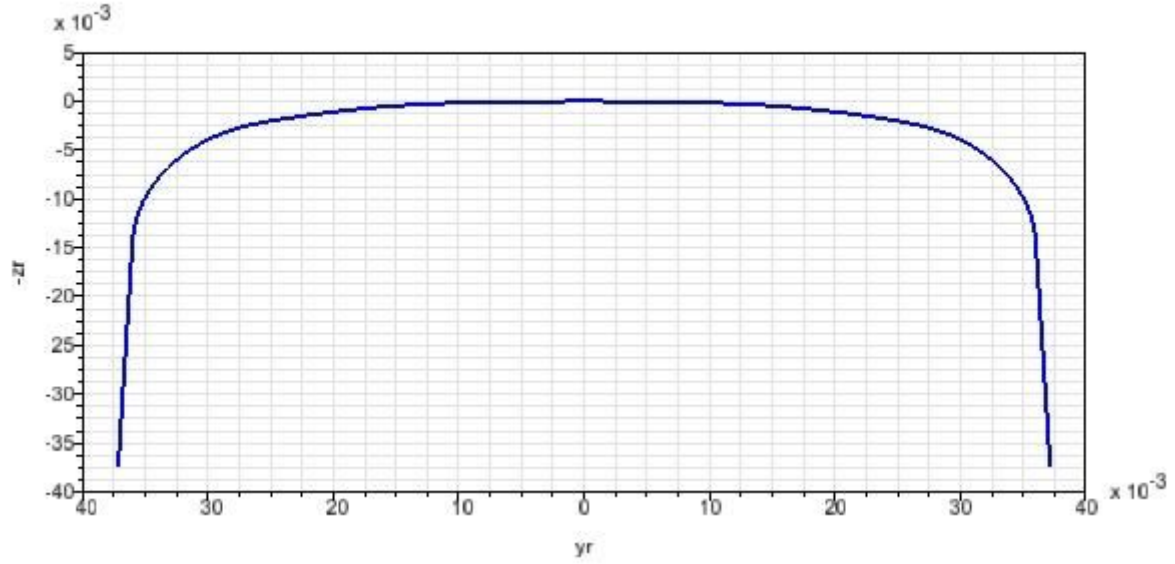


C23=-C32

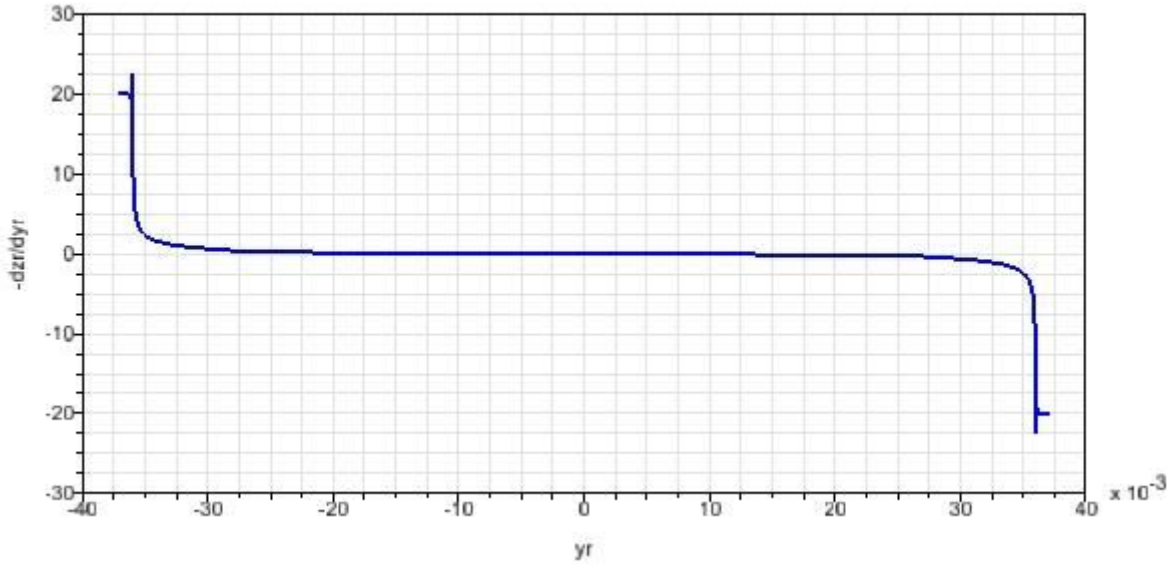


Rail profile

Profile



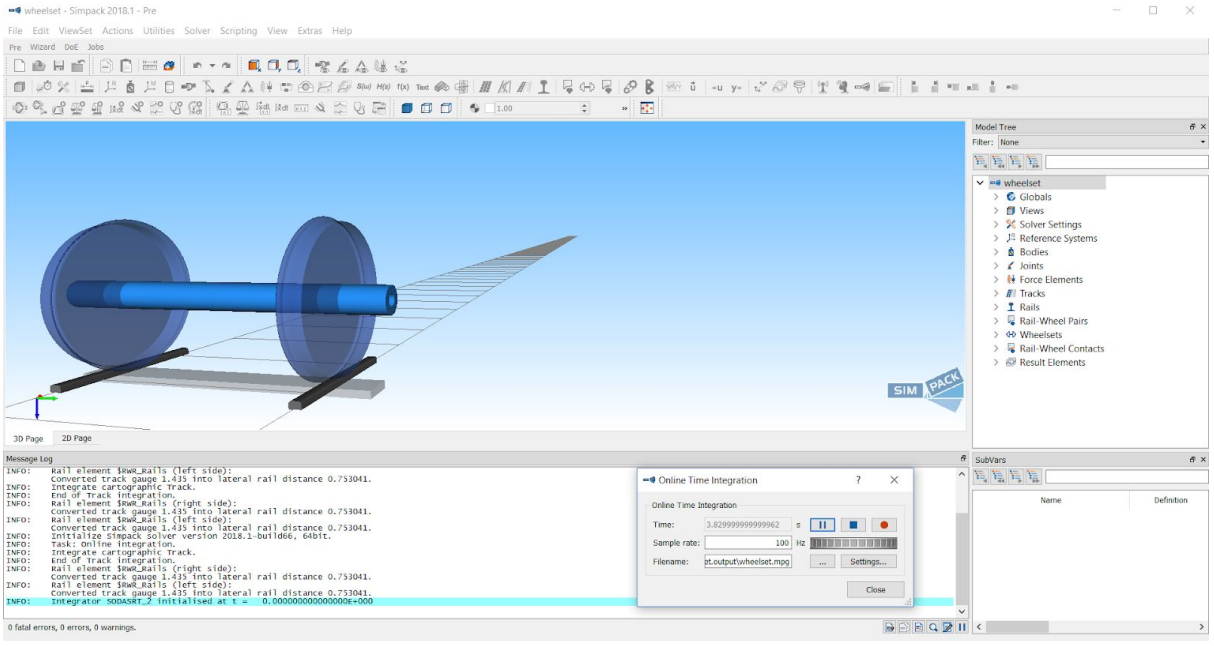
Gradient



Single Wheelset Model

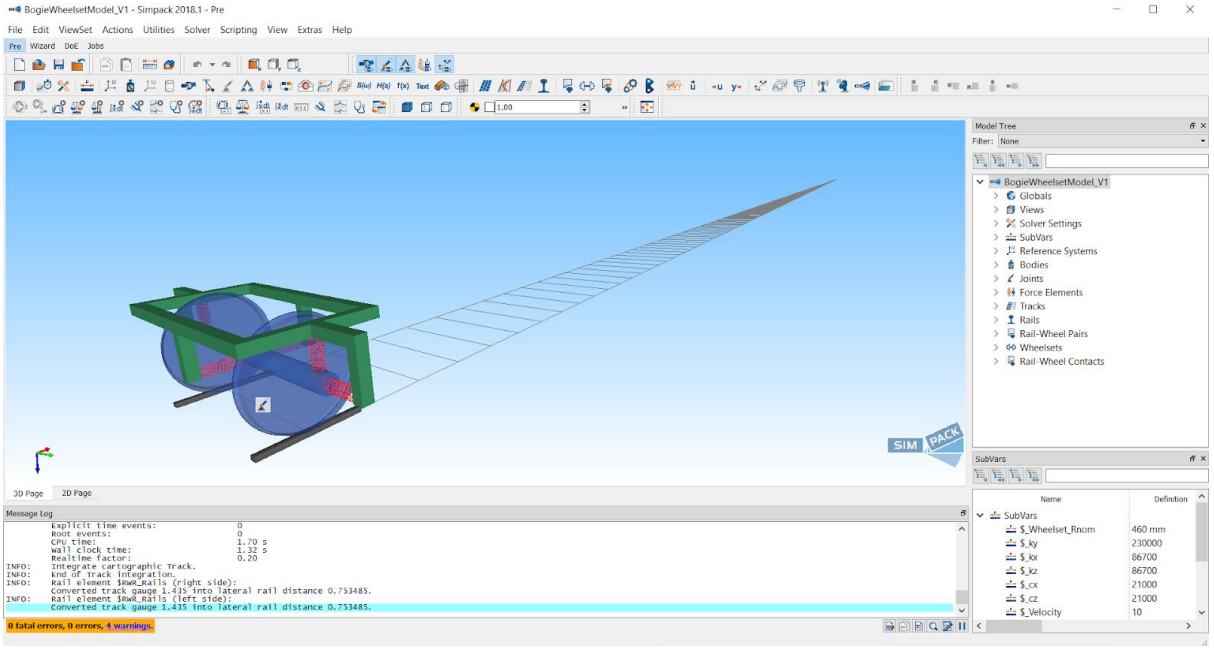
A single wheelset model with track, bolster is created in geometric modeling for basic verification of wheelset kinematics.
It is tested for a constant velocity over a straight track.

File : wheelset



A single wheelset with springs in x, y and z direction were added just to see it's motion behavior. The wheelset is not running properly in this case because of unstable eigenvalues.

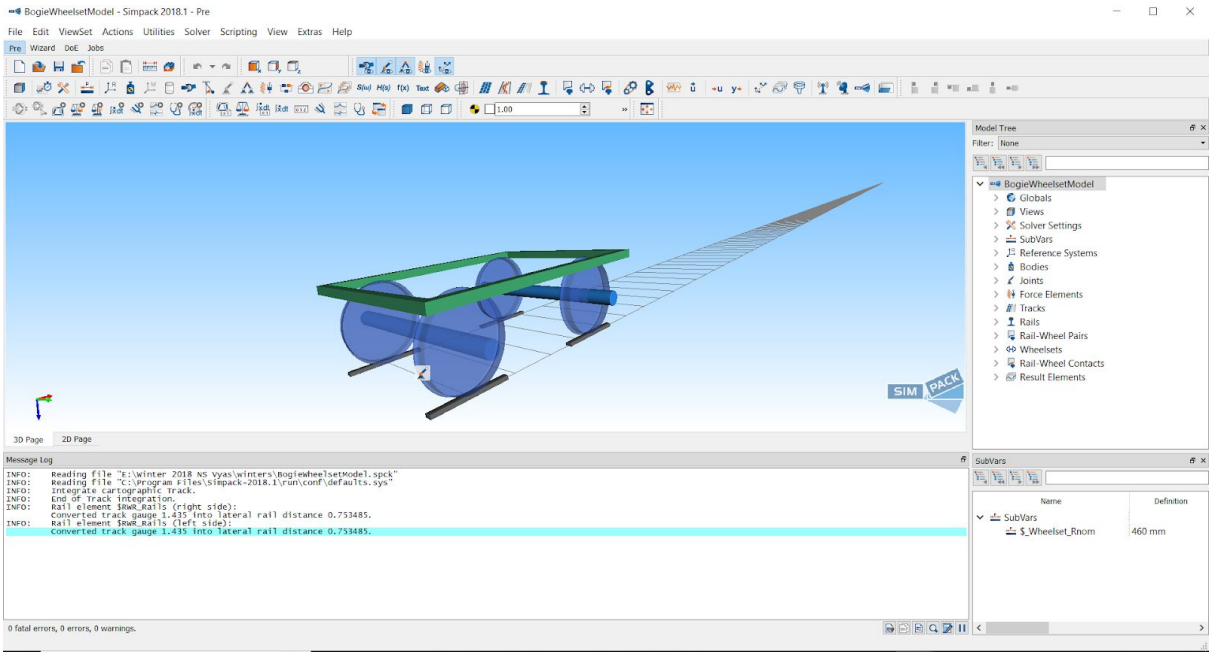
Folder: RRVD_Report\Rajesh\winters\Single Wheelset
File: BogieWheelsetModel_V1



Double Wheelset Model with Frame

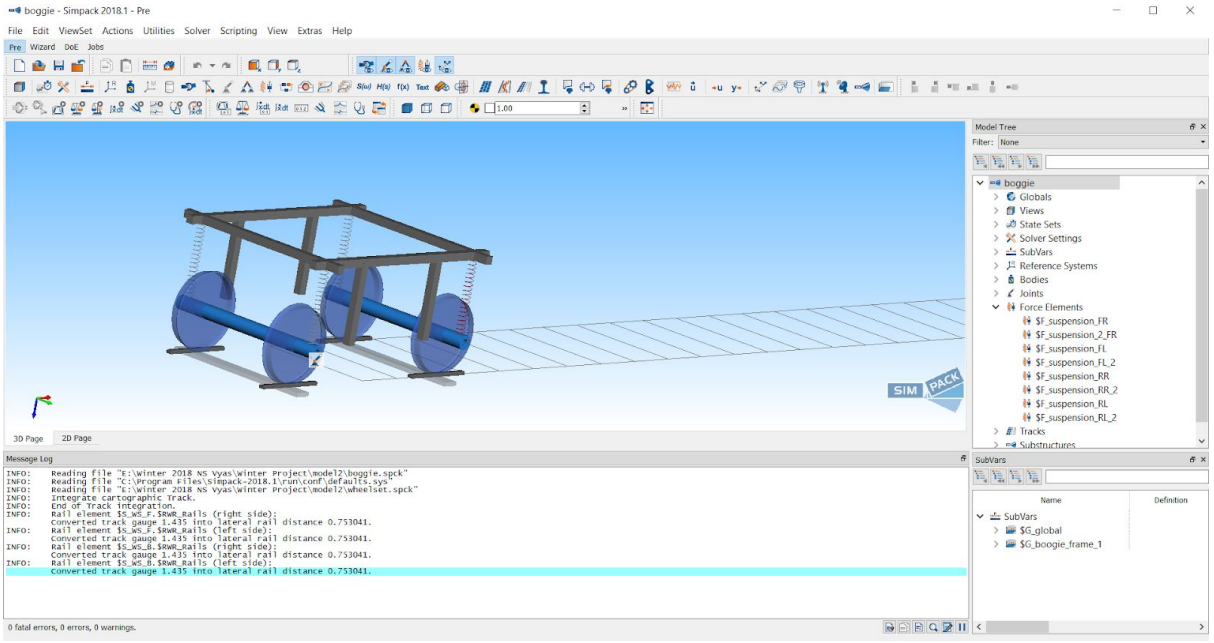
A simple bogie model is created through geometric modeling with 2 wheelsets and point to point forcing elements (springs).

Folder : winters
File : BogieWheelsetModel

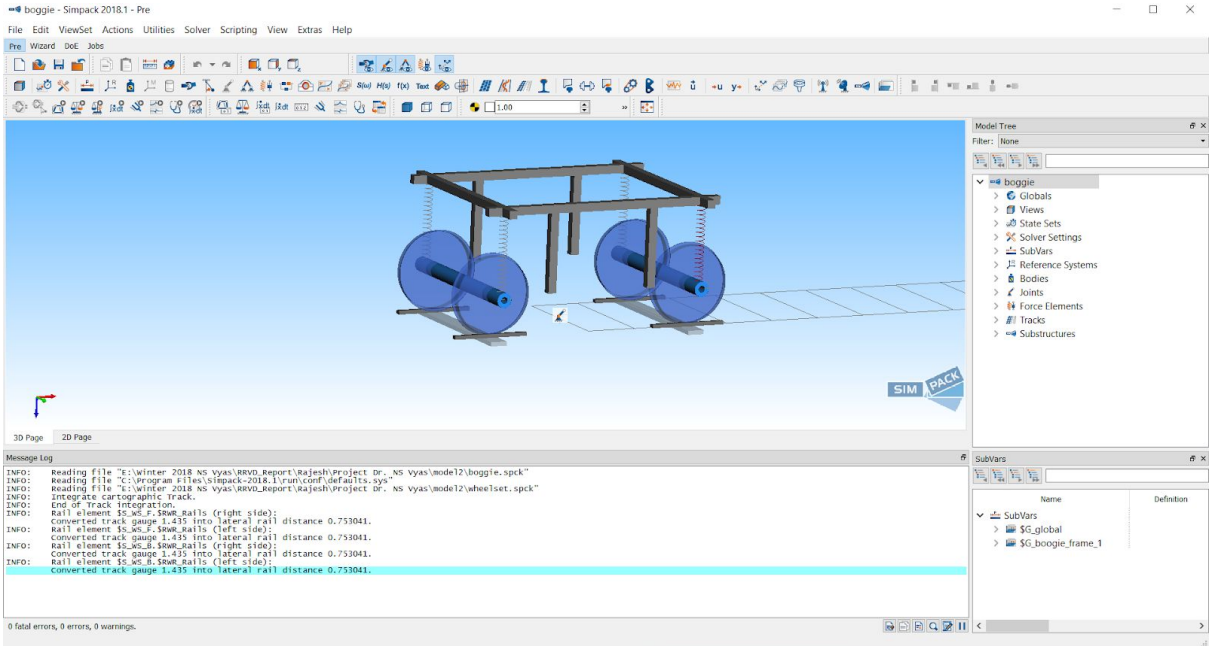


The wheelsets were connected to the frame using forcing elements in the x and z directions. After preloading the structure and making it come to its equilibrium state, eigenvalue analysis was done which showed that the structure was unstable(due to lack of forcing elements in the y direction).

Folder : Winter Project/model2
File : boggie

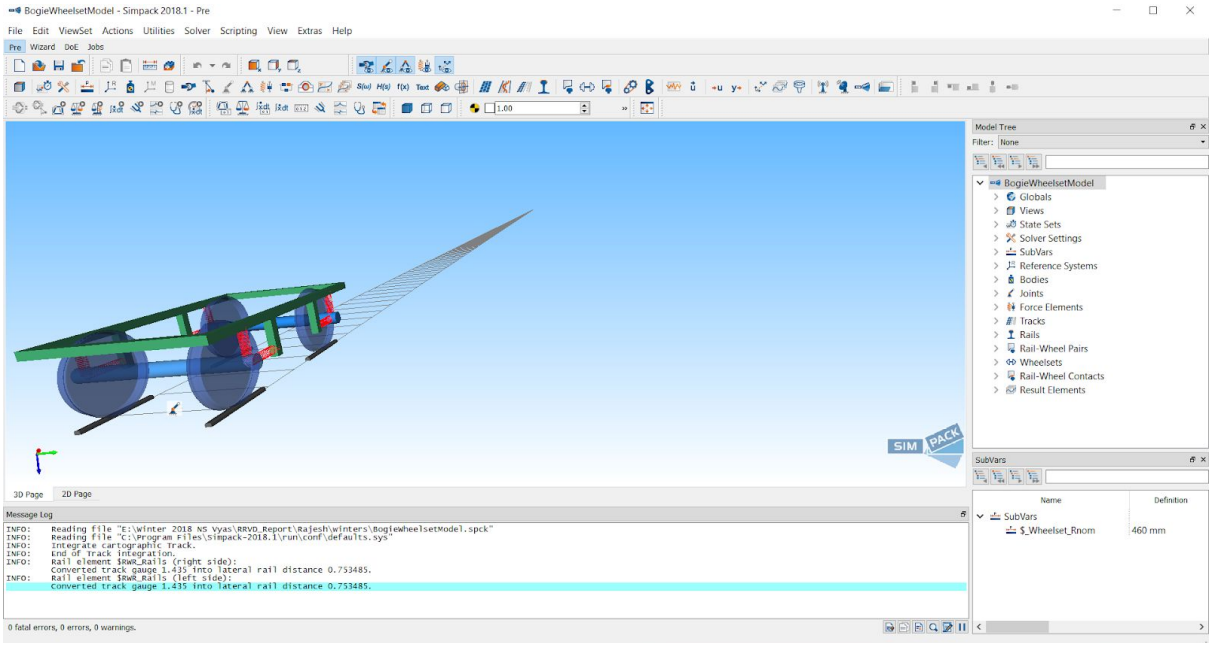


Folder : RRVD_Report\Rajesh\Project Dr. NS Vyas\model2
File: boggie

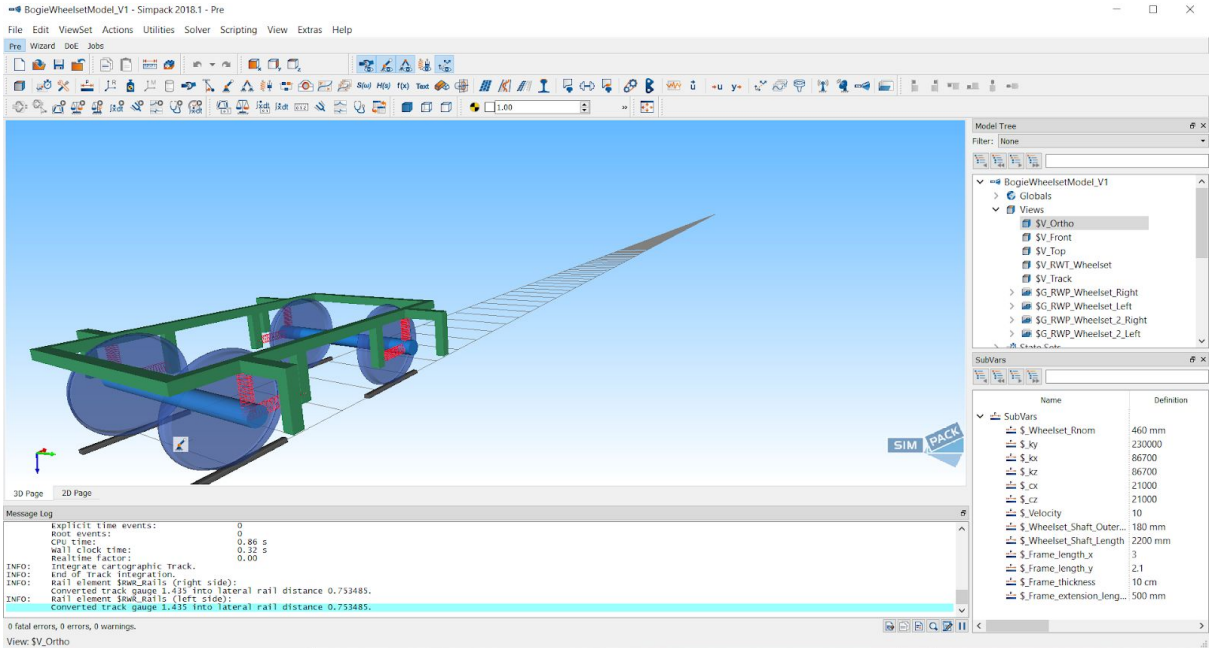


The two wheelsets were now connected to the frame using point to point forcing elements in x, y and z directions and eigenvalue analysis of the model was done to check the stability of various modes. The wheelset was now running.

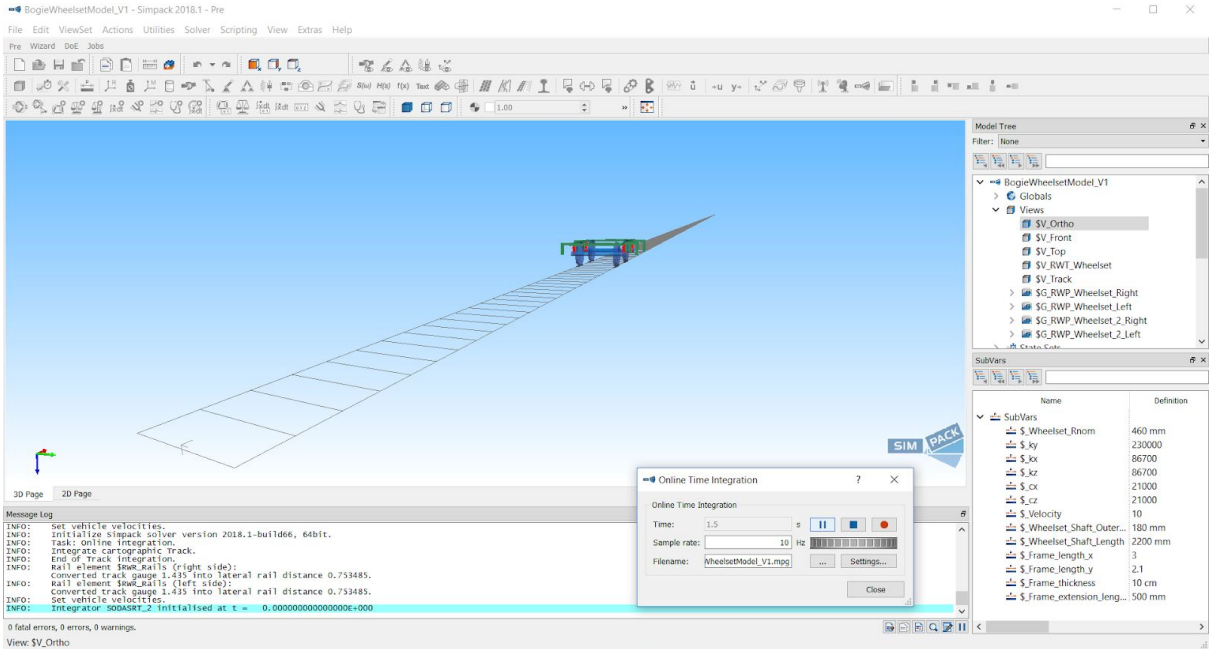
Folder: RRVD_Report\Rajesh\winters
File: BogieWheelsetModel



Folder: RRVD_Report\Rajesh\winters
File: BogieWheelsetModel_V1

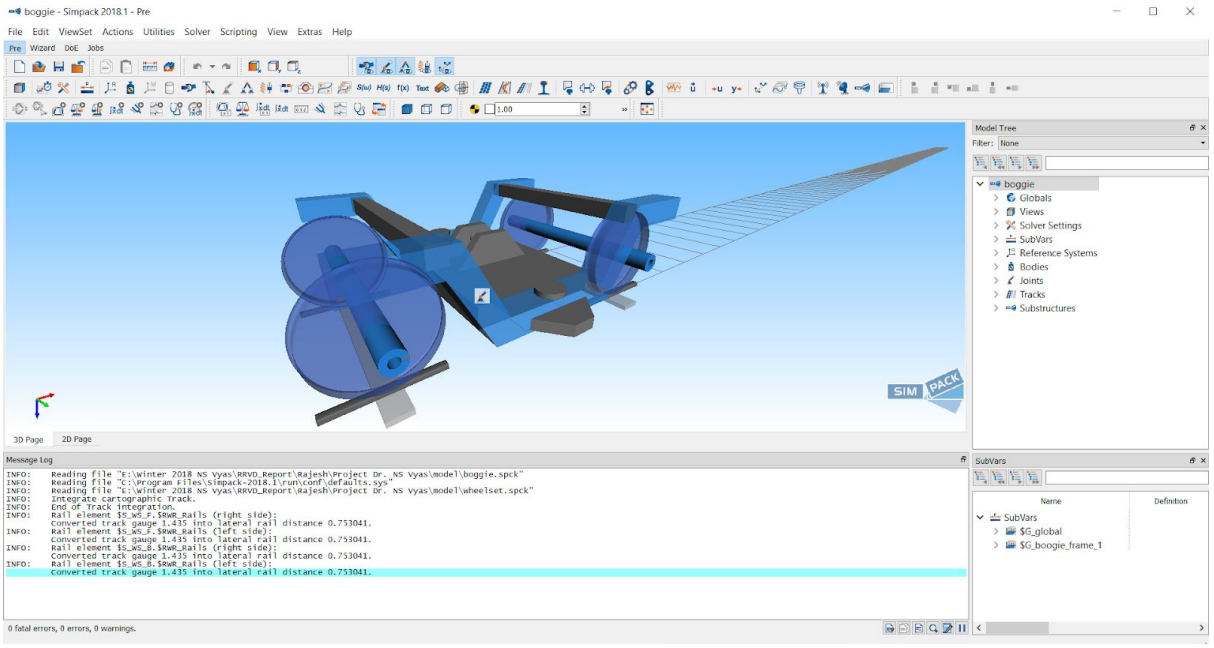


Remarks: Running, See the figure below.

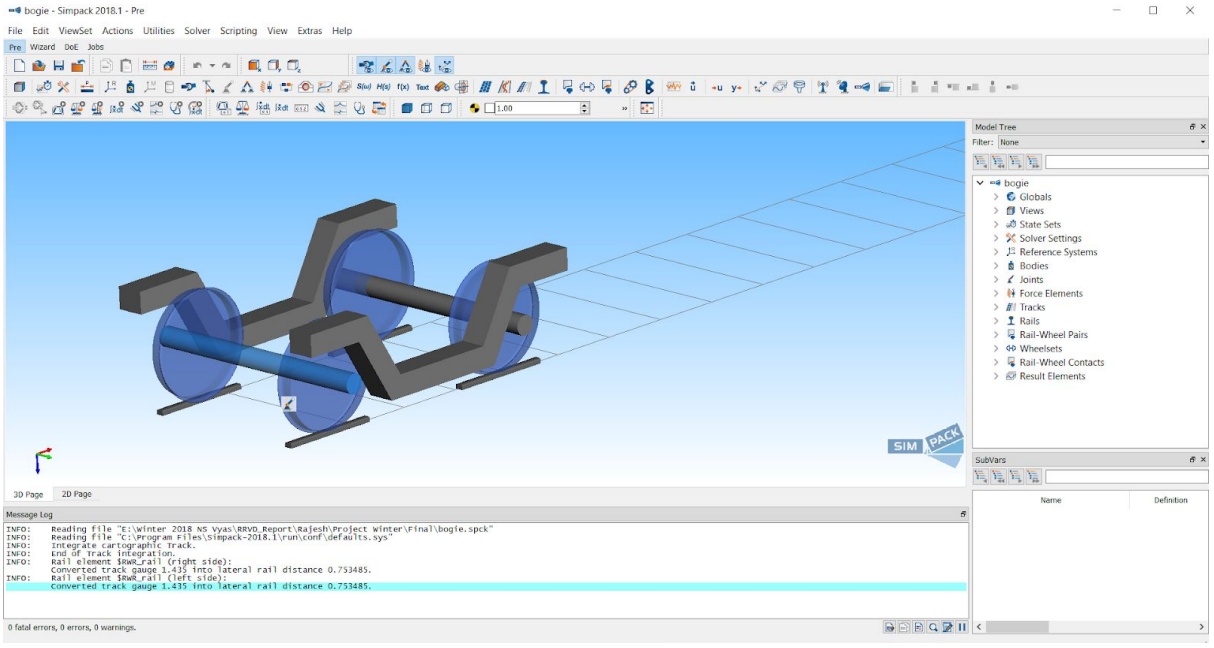


A model of the bogie was made but we did not proceed ahead with this model because of the complexity involved and were trying with the simple models of bogies.

Folder : RRVD_Report\Rajesh\Project Dr. NS Vyas\model
File: boggie
Remarks: Not running. It is Just a model made.



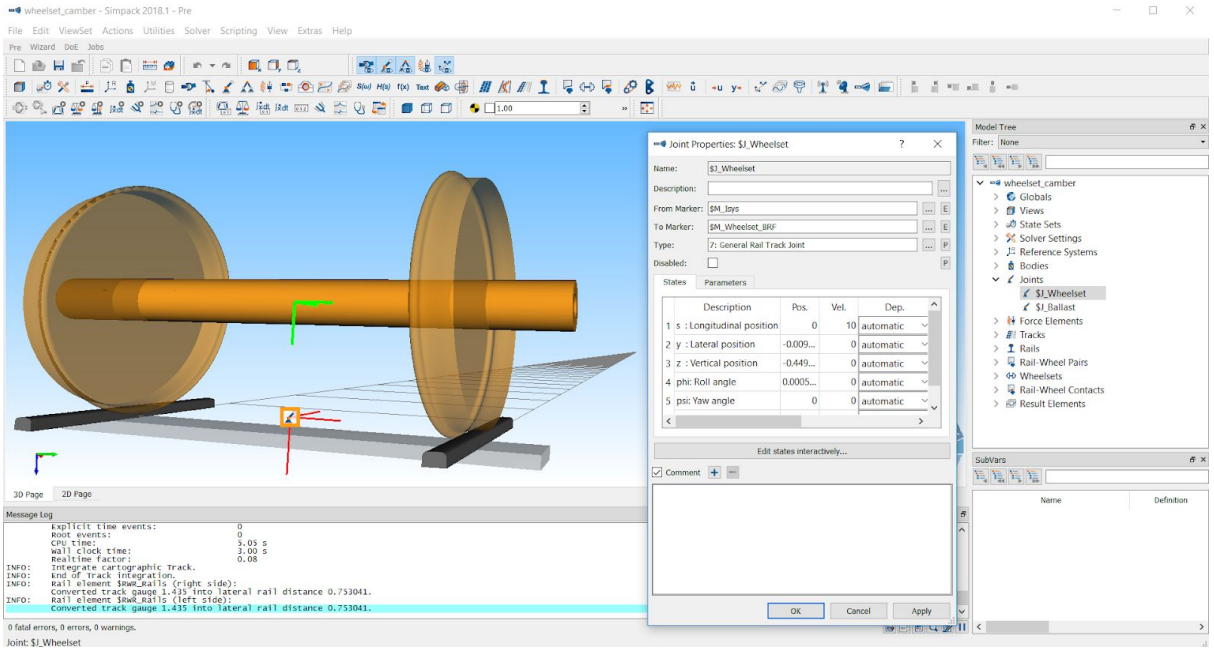
Folder : Folder: RRVD_Report\Rajesh\Project Winter\Final
File: bogie



Uncertainties imparted to the wheelset

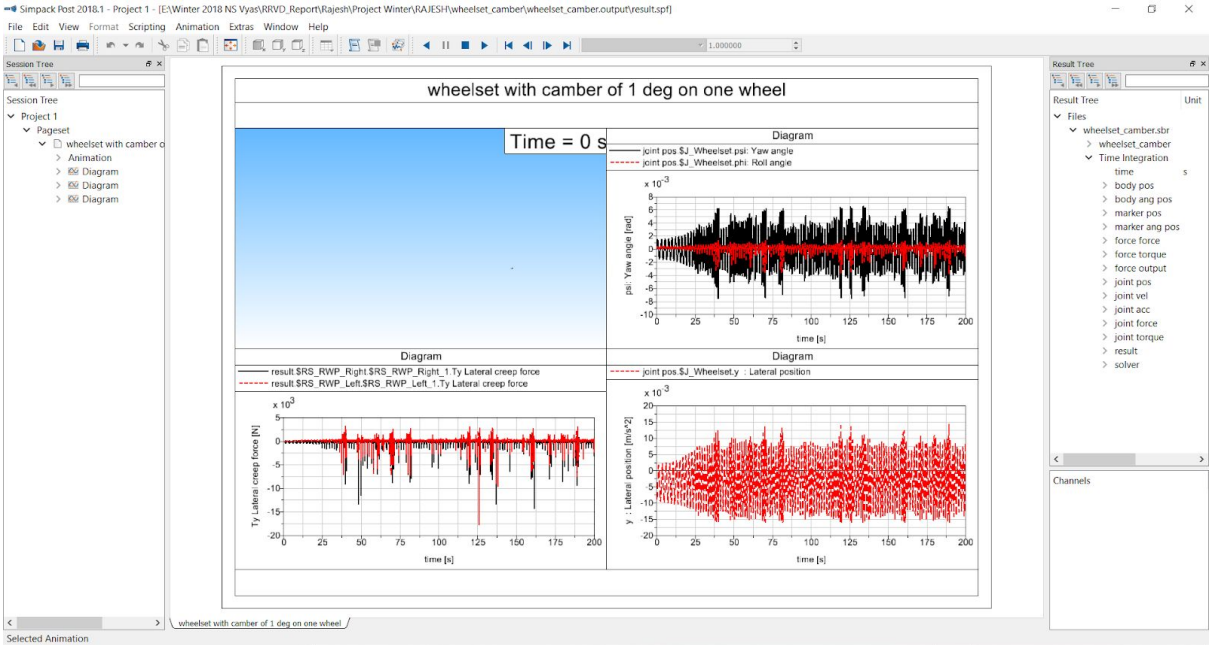
1. Camber

Folder: RRVD_Report\Rajesh\Project Winter\RAJESH\wheelset_camber
File: wheelset_camber



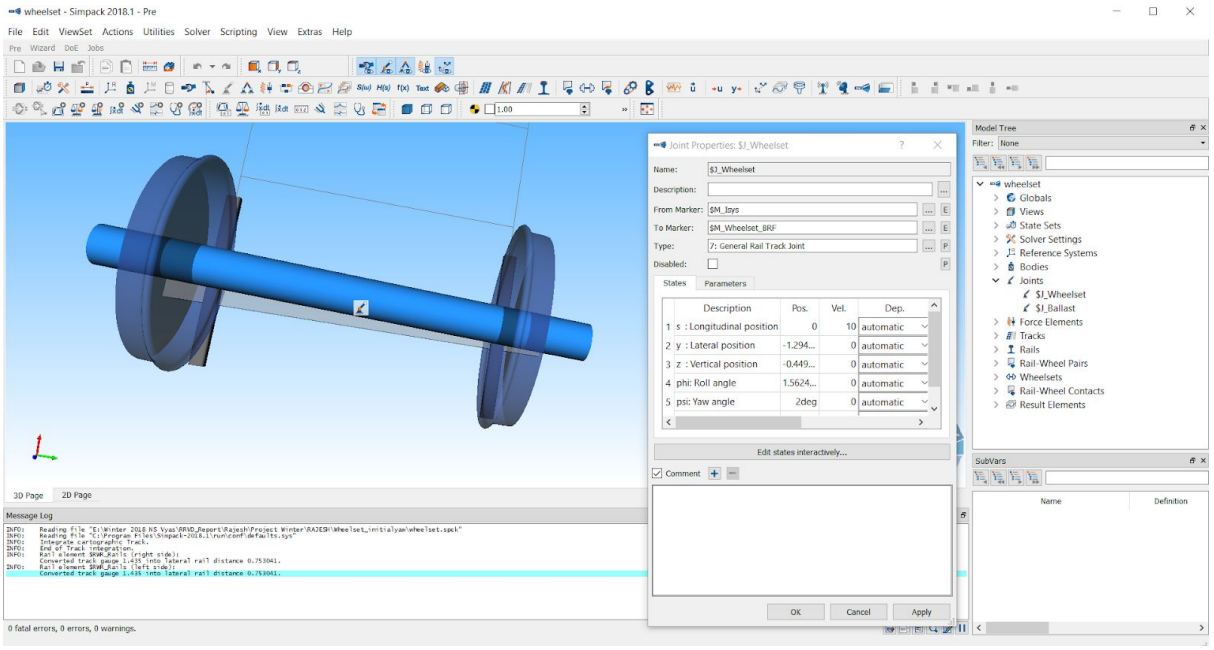
Camber of 1 degree was the imparted to the wheelset and its motion behavior was visualized using Simpack post. The next figures show the output signals as well as the animation.

Folder: RRVD_Report\Rajesh\Project Winter\RAJESH\wheelset_camber\wheelset_camber.output
File: result



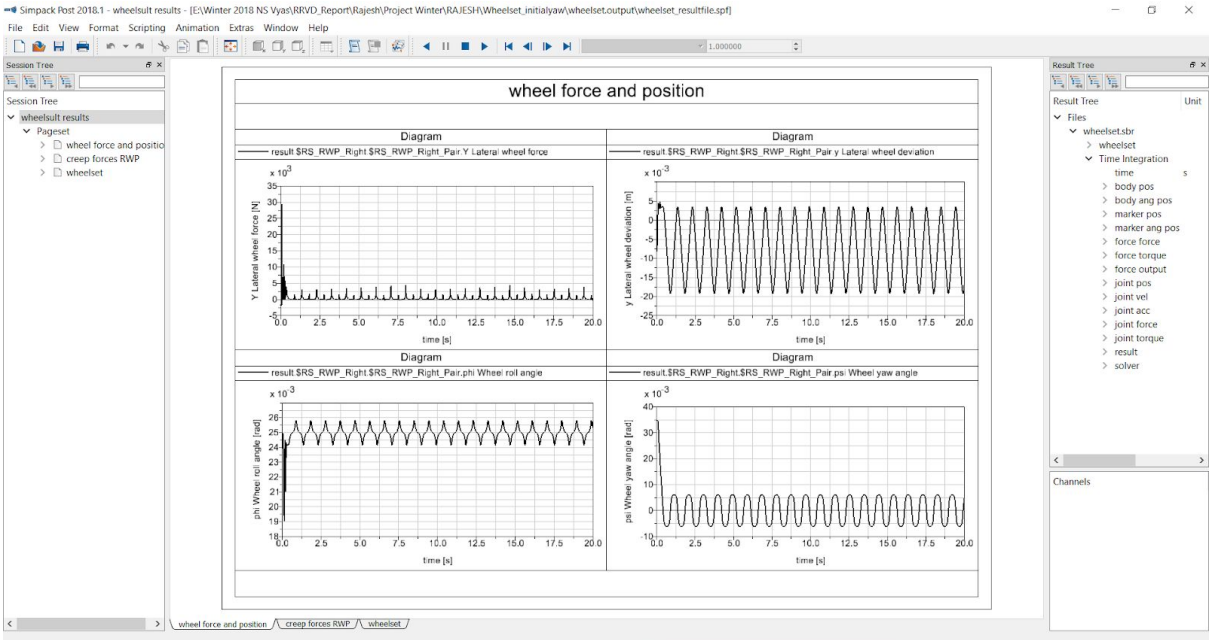
2. Yaw

Folder: RRVD_Report\Rajesh\Project Winter\RAJESH\Wheelset_initialyaw
File: wheelset



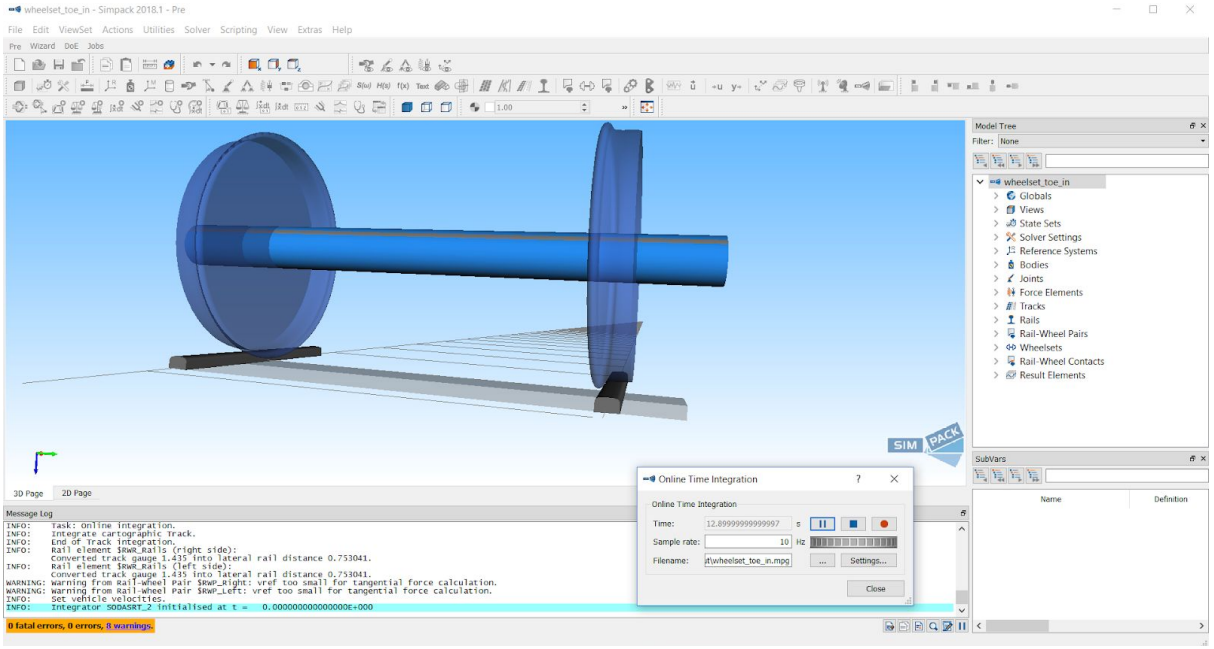
Initial yaw of 2 degrees was imparted to the wheelset and its motion behavior was visualized using Simpack post. The next figures show the output signals as well as the animation.

Folder: RRVD_Report\Rajesh\Project Winter\RAJESH\Wheelset_initialyaw\wheelset.output
File: wheelset_resultfile



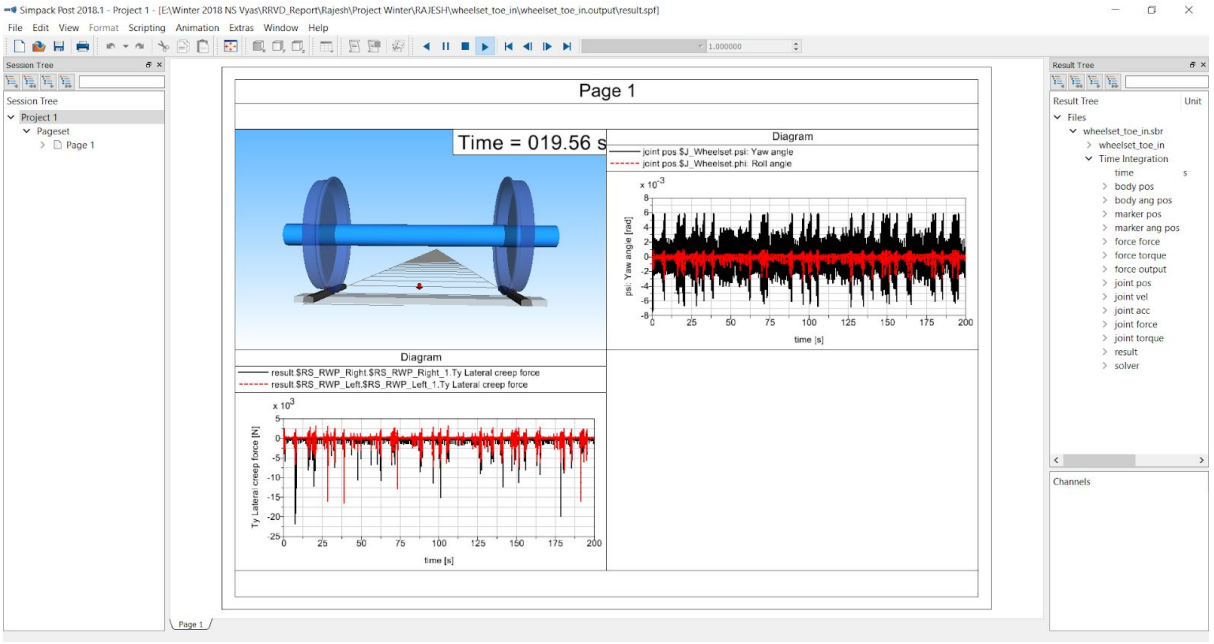
3. Toe in

Folder : RRVD_Report\Rajesh\Project Winter\RAJESH\wheelset_toe_in
File : wheelset_toe_in



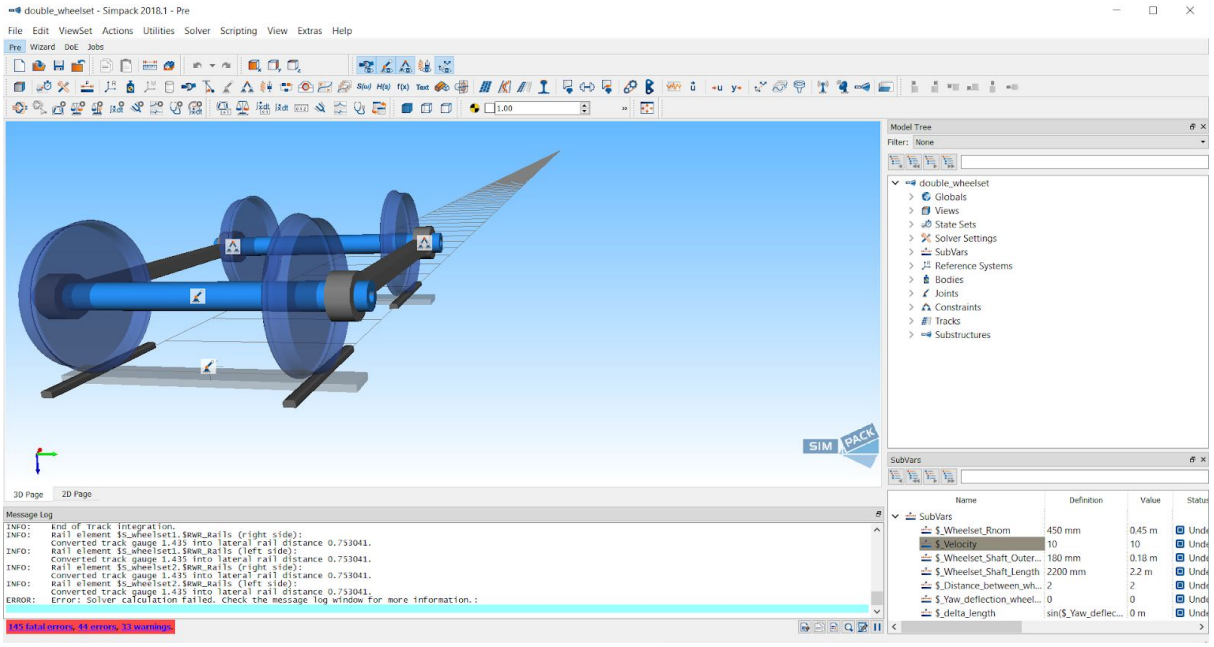
An initial toe in was given to the wheelset due to which the wheelset ran for some time but eventually derailed. The below figures from SImpack post show the motion behaviour on imparting the toe in to the wheelset.

Folder : RRVD_Report\Rajesh\Project Winter\RAJESH\wheelset_toe_in\wheelset_toe_in.output
File: result



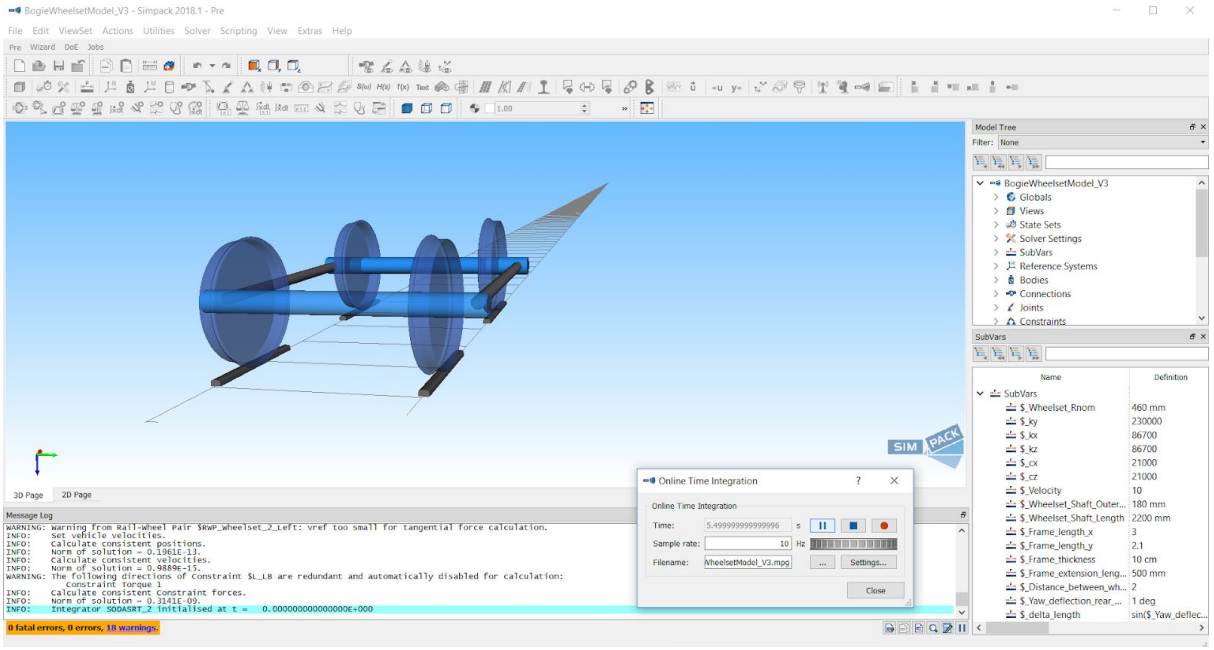
The wheelsets were connected on both sides by means of axles. The joints between the wheelset and the axle was created in such a way to mimic the bearing. In the axle the degree of freedom corresponding to the rotation of the wheelset was left free while all the other degrees of freedom were locked. But the 4 joints were over constrained (the solution is yet to be figured out) and the model did not run correctly.

Folder: RRVD_Report\Rajesh\winters\v3_Aditya
File: double_wheelset

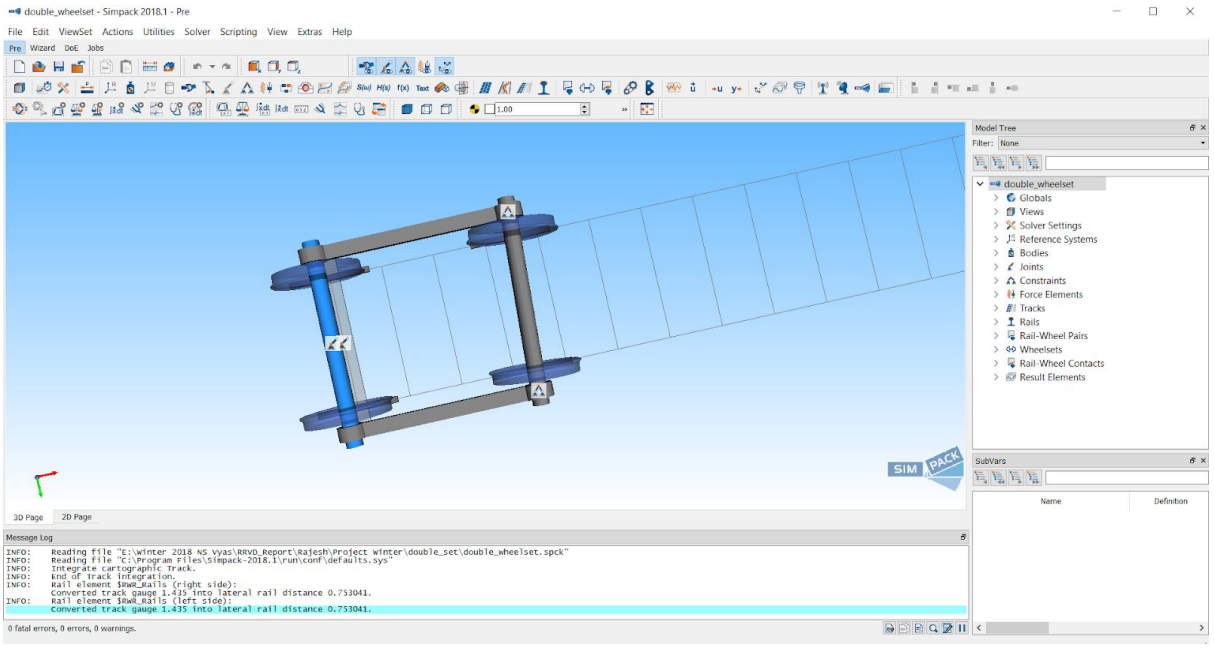


We tried to impart uncertainty in the full wheelset also by giving it a yaw of 2 degrees. The model is running but the yaw given is automatically getting adjusted to zero because of maybe joint constraints and this needs to be figured out so that the motion behavior can be analysed. We had also tried to give some uncertainties by making one axle a little smaller than the other axle so that one of the wheelsets gets a yaw and tried to study the motion behavior but were not successful.

Folder: RRVD_Report\Rajesh\winters
File: BogieWheelsetModel_V3

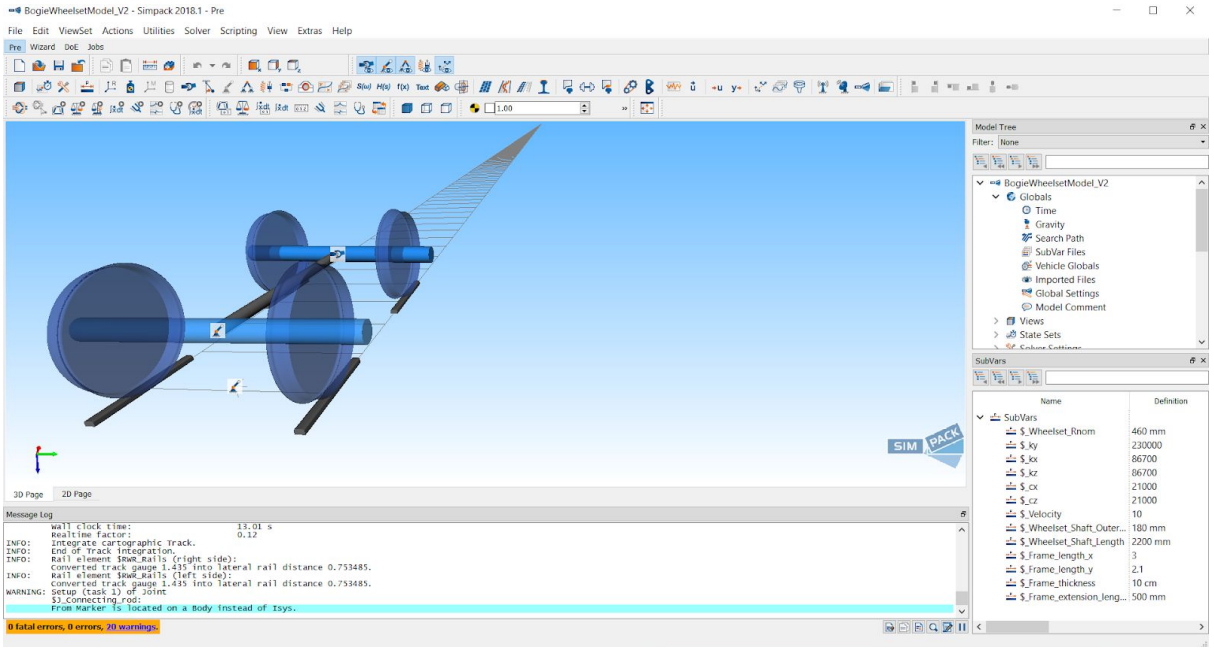


Folder: RRVD_Report\Rajesh\Project Winter\double_set
File: double_wheelset

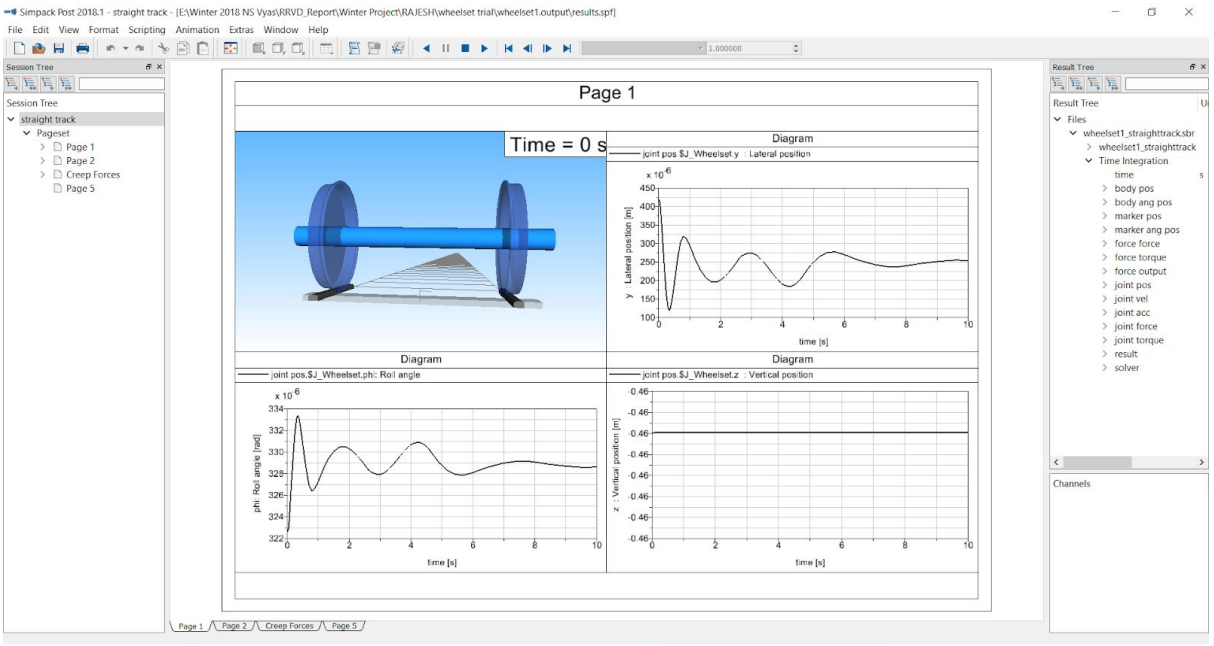


The two wheelsets were connected using a single axle and two joints on the axle were defined as a joint and a connection. These joints had only one degree of freedom free so that it allowed the wheelsets to have an angular velocity and all the degrees of freedoms were locked.

Folder: RRVD_Report\Rajesh\winters
File : BogieWheelsetModel_V2

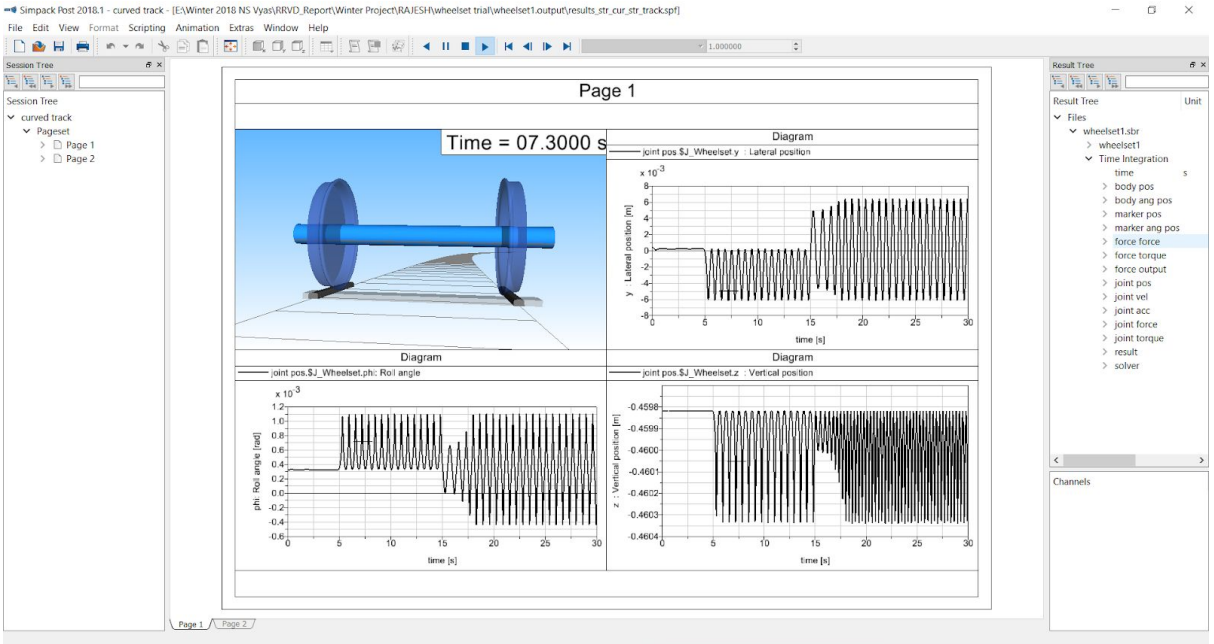


Folder: RRVD_Report\Winter Project\RAJESH\wheelset trial\wheelset1.output
File: results



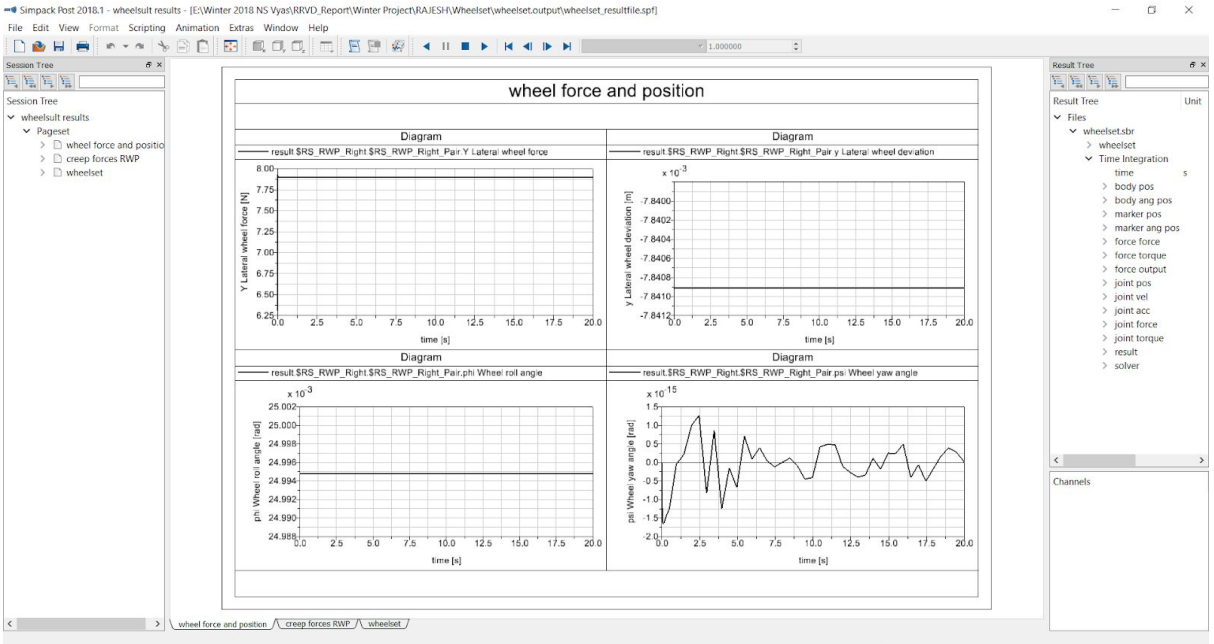
Motion of wheelset on a curved track

Folder: RRVD_Report\Winter Project\RAJESH\wheelset trial\wheelset1.output
File: results_str_cur_str_track



A curved track was made and the motion behavior of wheelset was observed which one can see in the next figure. This was done so as to see how the wheelset negotiates a radius of curvature.

Folder: RRVD_Report\Winter Project\RAJESH\Wheelset\wheelset.output
File: wheelset_resultfile



Moving load on a beam using Ansys

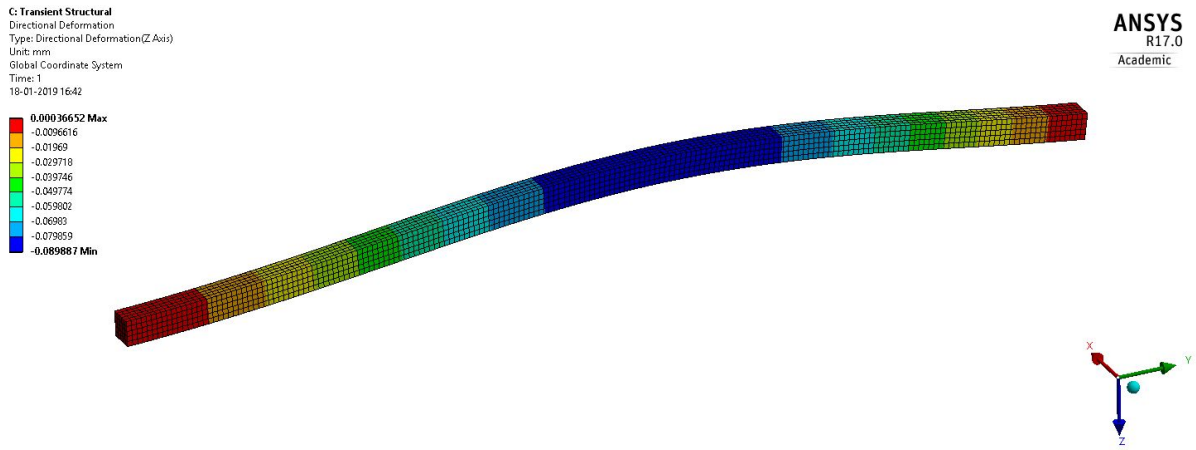
A beam with moving load was modelled to see the motion behavior of the rail track when the train is running on it.

The beam is made of structural steel of dimension 190X5X5m3. The beam is made with multiple thin features on one of the surface using ANSYS Geometry Modeller.

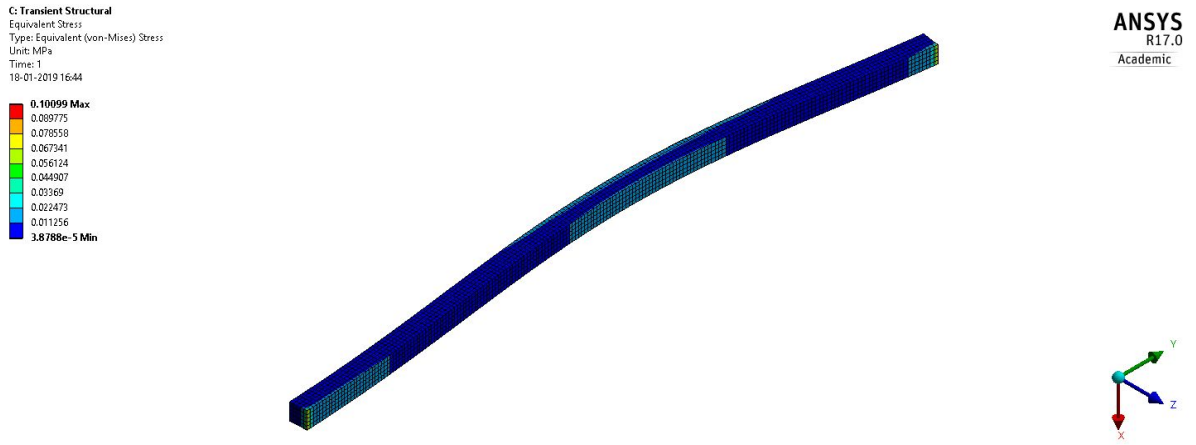
A 2D Static structural analysis is performed for a moving load on the beam. The moving load is imparted through a time-dependent forcing input which is applied on multiple sections of the face. The face of 5X190m is divided into 19 equal sections with different instants of forcing so that it approximately mimics a moving load problem.

The beam was meshed using Mesh Sizing method using cubic elements of 1m3 . Below is the image of the meshed beam model.

The figure below shows the total deformation of the beam when a force of 10kN is applied.
The beam is fixed in all degrees of freedom at the opposite edges at the two corners of the beam.



The figure below the Von Mises stress for the above given force and boundary conditions.



This problem need to be extended to a circular beam but there were problems in creating thin features on the circular inner cross-section in ANSYS. We weren't able to divide the circular cross-section into multiple sub-sections for applying moving load as done approximately in the above problem.

Beam crack modeling

ANSYS Mechanical APDL was used to model a beam with a crack.

The beam is modeled as two half sections with solid 8 node brick elements. They are meshed individually and then all the nodes are connected except at the crack. A crack of 10% is initiated in the beam at the center. Structural analysis was performed on the beam for a constant force at one of the ends with the other end fixed.

The moving load problem was not implemented on APDL beam model.