Static and Dynamic Analysis of Modular Cantilever System

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INTRODUCTION: Modular cantilever System is a swivelling type structural member of Railway OHE which supports two levelled cable(Contact and Catenary wires with droppers) structure. MCS allows smooth current collection while passing of pantograph and additionally transfers all vertical, lateral and bending loads to the mast.

In this analysis work, lightweight, unique, foldable and robust design of the newly designed cantilever system has been analyzed for dynamic loading conditions using MBD module of COMSOL™ Multiphysics. Transient study has been carried out for the MCS since moving pantograph affects behavior/performance of the MCS.

DESIGNS OF MODULAR CANTILEVER SYSTEM:

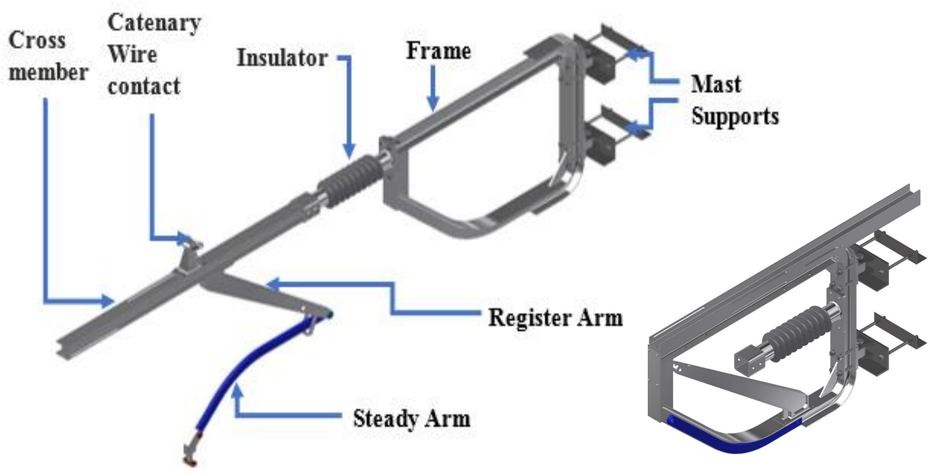

Figure 1. Raychem RPG™ Foldable MCS with Folded View

DYNAMIC ANALYSIS:

MCS undergoes millions of passes of pantograph in its service life. For each pass, fluctuation in contact generates force due to wave propagation having frequency less than 20 Hz[3]. Boundary conditions are applied for 3 cases 5, 10 & 20 Hz to capture the total displacement and induced von mises stresses to predict real life scenario and failure of MCS.

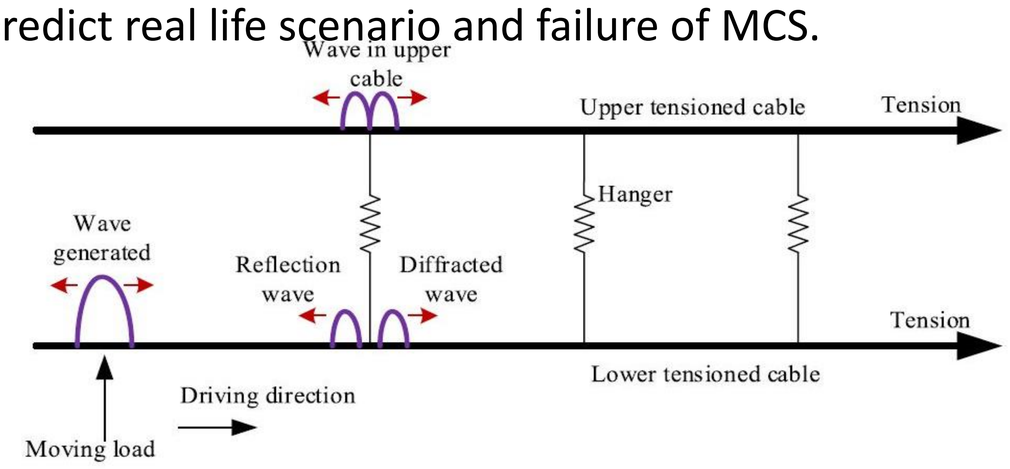

Figure 3. Wave propagation of moving load[3]

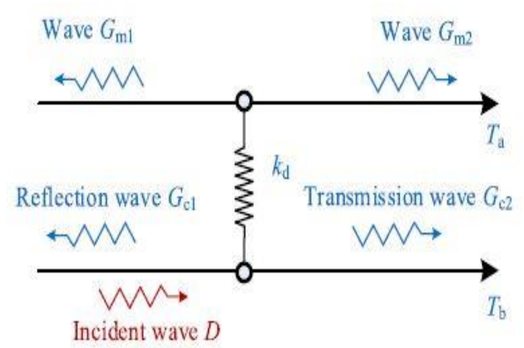

Figure 4. Wave interaction with catenary system

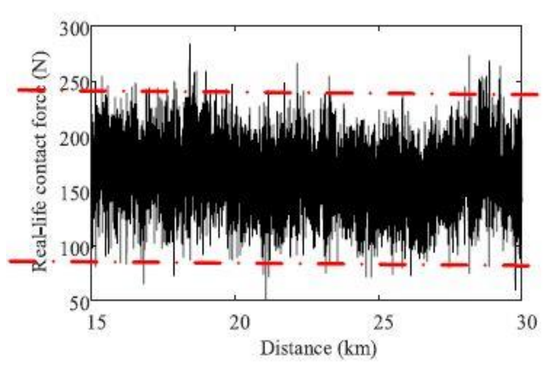

Figure 5. Force variation w. r. t. distance travelled by pantograph

Figure 3 shows wave propagation of moving load due to pantograph and its transfer in the contact and catenary wire through droppers.

Figure 4 shows that Part of total wave gets transmitted while part of the wave gets reflected back in both wires. Figure 5 Real life contact force between pantograph and overhead wire. Figure. 6 shows Waveform for the sinusoidal wave plotted as per function for frequencies 5 Hz, 10 Hz and 20 Hz using COMSOL analytical function.

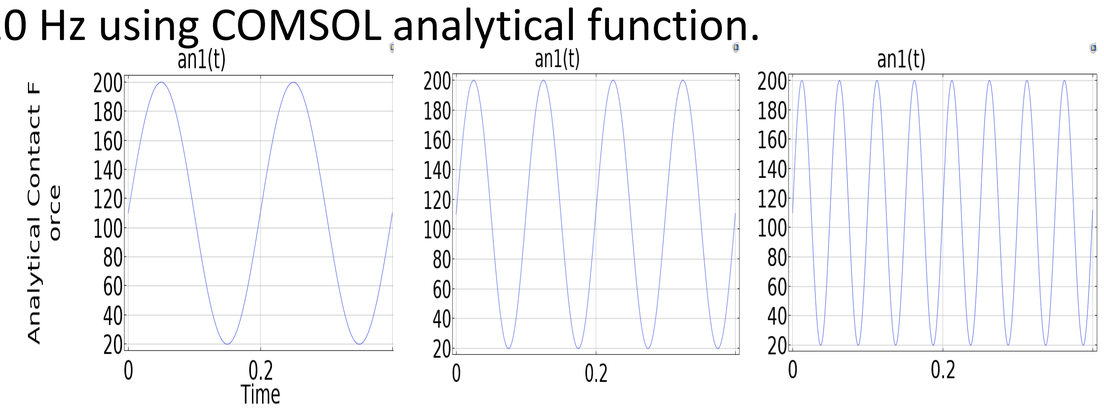

Figure 6. Analytical Contact force waveform for 5 Hz, 10 Hz and 20 Hz. in COMSOL™ Multiphysics

Wires	*Vertical Component (N)*		*Horizontal Component (N)*	
Catenary wire	Dead Load + Ice Load + Tensile Load	1600+385+315 = **2200**	Stagger + Wind Load + Curve Track	200+600+ 400 = **1200**
Contact wire	Pantograph dynamic force	**110+90* sin(2*Pi*f*t)**	Stagger +Wind Load +Curved Track	200+500+ 400=**1100**

Table 1. Dynamic Force Calculation for simulation

RESULTS AND DISCUSSION:

Von mises stress and total displacement for 5Hz, 10 Hz and 20 Hz were calculated and have been discussed in table 2. It has been observed that maximum value of the Von mises stress is 209 MPa which is well below allowable stress with FOS of 1.5 while maximum upliftment of the tip of the steady arm is 23.1 mm, much lesser than 100 mm as mentioned in literature & handbook[2,3].

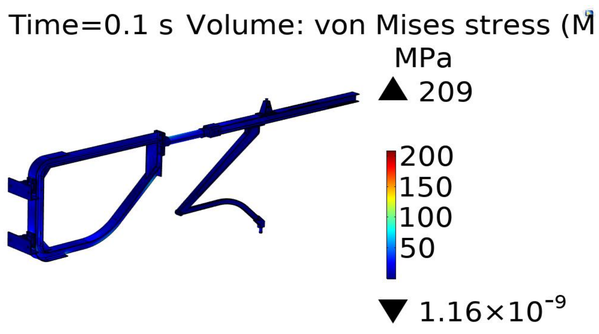

Figure 7. Von Mises Stresses at 0.1 sec

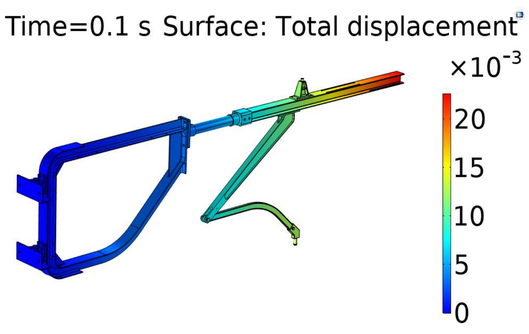

Figure 6. Total Displacement at 0.1 sec

Type of Design	Frequency of wave (Hz)	Number of cycles for 0.4 second	Maximum deflection (mm)	Maximum Von Mises stress (MPa)
Foldable MC	5	2	14	141
	10	4	20.6	195
	20	8	23.1	209

Table 2. Von mises stress and Maximum displacement in MCS

CONCLUSIONS:

1. An optimized design is obtained after series of iterations. Values of the induced Von Mises Stresses for both Static and dynamic loading conditions in the assembly of the all the Modular Cantilevers are well within limit of allowable stress.
2. The maximum upliftment of the tip of the steady arm is within allowable limits.

REFERENCES:

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