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The riding characteristic is the most significant of the factors that make the railway journey attractive at a competitive price. The design of coaching stock bogies in the Pakistan Western Railway needs a re-examination to improve their riding characteristics on the track. The Author has described the trials conducted and the results obtained by the joint effort of Pakistan Western Railway and Messrs Linke-Hoffmann Bucch, a German firm of carriage manufacturers.

The sum total of the measures which improve the well being of a passenger and reduce the fatigue during a journey is termed as riding comfort. Riding comfort depends upon car body vibrations, running noises, dust nuisance, temperature, lighting and general aesthetics. The paper focus is on the most significant factor of car body vibrations. Transmissibility ratio i.e., the capacity of the running gear (the bogies) to transfer shocks and impacts in the vertical and horizontal directions into bearable type of vibrations determines the running quality of a vehicle and is a function of the ratio of the frequency of the existing forces to the natural frequency of the suspension gear of the car body. Rail joints, wheel eccentricity, rail surface irregularities, shaking action of the wheel pair, track gauge variations, and lead alignment of track etc generate forces that give rise to vertical & lateral oscillations. The natural frequency of the suspension gear of the car body is dependent upon specific deflection of the springs, vehicle mass, system inertia and link arrangement.

Car body movements are due to oscillations along the three principal axes i.e. bouncing along the Z-axis, fore & aft movements along the longitudinal axis (X-axis) and lateral oscillation along lateral axis (Y-axis) and the rotational movement about these principal axes, known as nosing, rolling and pitching respectiely. The oscillations are coupled in simple combinations to avoid complexity of vehicle dynamics. If all of these oscillations and combinations are taken into consideration then only digital computer can solve the resulting numerous simultaneous equations at the design stage of the vehicle. Presently, therefore, the natural frequencies of bouncing, nosing, swaying, lateral and rolling oscillations are considered in simplified relations for the design purposes. With the help of natural frequencies, the spring characteristics and swing link proportions are chosen in such a way that resonance does not occur at operational speeds and vehicle is not unduly sensitive to vertical and lateral impacts. The determination of damper characteristics for reducing amplitude of oscillations within acceptable limits at resonance, without adversely affecting the riding quality of the vehicle at speeds above that of the resonance speed, becomes easy with the determination of natural frequencies. Lateral and nosing frequencies, combined oscillations (swaying) and sinusoidal motion of wheels secured to common axle, dampers ratio of amplitude and vertical oscillations are determined by using the current theories on bogie design.

Rolling Stock Test Department of Reisch Bahn at Berlin-Grunewald and Dr. Eng. Sperling studied various mathematical terms like spring stiffness damping factor etc. in relation to human sensations. The object was to establish a mathematical relationship in terms of amplitude and frequency of lateral and vertical vibrations and an index value specifying the running quality of a coach. Study of human reactions have shown that sensation of discomfort is twice as great in the case of lateral oscillations as for the vertical ones for a particular frequency. The same study established that a frequency range of 4-8 C.P.S. produces the maximum discomfort whereas frequencies above 50 C.P.S. get filtered by the human body, and cause no discomfort. According to the German Federal Railways Standards, the running quality evaluation mark ("Wertziffer WZ") of 3 to 3.25 is the lower limit of running quality in case of passenger coaches and 4 to 4.25 for goods stock. The evaluation mark of 1 is very good whereas 5 is dangerous for operation.

Theoretical design must be tested in actual conditions because of the numerous variables involved. With the objective of a new suspension arrangement having a ride index value of 2.5 to 3, the German firm M/s. Link Hofmann Busch designed five different types of suspension arrangements for the light weight integral type semitubular coaches. In order to test all of the five alternatives, the firm also supplied three sets of prototype bogies in which any of the suspension arrangement could be icnorporated by suitably changing the springs of the secondary suspension. Harder primary suspension was classified as A, and the soft one was designated as B. The five combinations of suspension arrangements were named as A1, B1, A2, A3 & B4. Combinations 1, 2, 3, and 4 were achieved by suitably changing the springs of the bolsters. A3 and B4 bogies had higher specific deflections which made them unfit for lower class coaches.

The actual tests were carried out between Kissan and Renala Khurd Railway Stations for an overall period of 3 months and 9 days. The object was to determine the effect of change of suspension parameters on the running quality and then to select the best possible combination for good riding characteristics on the P.W.R. track. The first few trials eliminated most of the combinations of spring gears and coach No. WGNT 4307 was used mostly for this purpose. For measuring WZ values, Inductance Type Accelero-meters, Amplifiers Bridge Type (single channel) and Analog Computer were the main instruments used. Resistance Strain on Gauge, Amplifier Bridges Type W (six channels), Magnetic Tape Recorder and Three Channel Recorder were used for the strain measurements. 142 trial runs on the test track were conducted. The suspension arrangements with a WZ value higher than 3 at 60 m.p.h. were eliminated. The test results were in close agreement with the theoretically anticipated predictions.

The detailed analysis of the test results revealed that on the existing tracks of Pakistan Western Railway, all coil spring bogies with suspension arrangement characteristics corresponding to proto-type A2 for the lower class and proto-type A3 for the upper class coaches are the best choices. The two suspension arrangements have axle springs upon specific deflection of the springs, vehicle mass, system inertia and

of the same characteristics. Choice of the two arrangements simplifies maintenance and achieves standardization. A2 specifications are harder helical coil axle springs with helical coil spring at the bolster with a total static deflection of 0.56 cm per MP (0.217 in/ton) and distribution ratio of 30:70 between the primary and secondary springs. A3 has same primary springs as of A2 with a total deflection of 0.83 cm per MP (0.322 in/ton) distributed in the ratio of 20 : 80 betwen the primary and secondary springs.

Condition of wheel tyres has a great influence on the riding quality of a coach. Heat treated tyres, recently introduced on the Japanese National Railways can be used in Pakistan as these may be proved to be longer lasting. Composite brake shoes can also be useful with regards to maintenance as their use results in imparting a polished surface to the wheel tread which has a good effect on ride index value. The economic comparison of cast iron brake blocks with composite brake shoes can only be done by actual experiments. The rubber fittings and shock absorbers may pose some maintenance problems because of climate and dust and can reduce the efficiency of shock absorbers. A close monitoring of the performance of the rubber fittings and shock absorbers in early stages of the introduction of A2 and A3 bogies is necessary. Adequate facilities for shock absorbers maintenance are also required for smooth running.