Finite Element Simulation Estimation of Wheel-base Reduction and Deformation Energy of a Typical Indian Motorcycle Crash at Known Impact Speed against Sedan Car

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I. INTRODUCTION

Increasing trends in the use of power two wheeler [PTW] on Indian roads is associated with increase in PTW related road traffic accidents (RTA) [1]. From the accident data collection activity on national highway-8 (NH-8) on the Delhi-Jaipur stretch in India, conducted by IIT D, New Delhi and NATRiP, a large number of PTW related RTA was observed [2]. In all instances, either less or no information related to pre-crash and post-crash motion, point of impact, and final rest position of the PTW was discernible from the crash site. In order to address the problem of what would have been V_{impact} of PTW involved in a crash on the basis of damage observed in PTW as well PV, an initial FE based simulation study for the most common motorcycle [M/C] used on Indian roads was done and is presented in this paper.

II. METHODS

Data to evaluate impact speed (V_{impact}) of PTW from crush data has been generated through crash tests [3-4]. V_{impact} was evaluated in terms of wheelbase shortening (Δw) due to bending of front forks against rigid barrier, stationary and moving passenger vehicle (PV). We present methods for FE based damage analysis to generate data useful for reconstruction. Crash simulations between M/C and PV have been used to establish the relationship between Δw and V_{impact}, deformation energy (E_{def}) and V_{impact}.

A typical representative Indian M/C model having 100 cc capacity, was selected for analysis and FE model was developed for simulation studies. Field measurements of the structural components such as frame, wheel, front forks, leg-guard, etc., was carried out to develop a 3D CAD model and subsequently an FE model was developed using HYPERMESH™. Appropriate material properties were assigned to the FE structural components (front-fork, crash-bar, handle, chassis, etc.) as per Indian Standards (IS) and Japanese Industrial Standards (JIS).

A FE model of the M/C is generally validated in rigid wall barrier test (RWBT). Following ISO: 13232 standards, barrier force is one of the variables to be measured in M/C dynamic testing [5]. FE simulation for RWBT was done to verify that the model developed acts as a unit and reasonable wall forces were produced following the proper dynamics of a crash event.

The Ls-Dyna™ FE package is used for dynamic rigid wall FE simulation. Wall Impact force for the typical Indian FE model, shown in Fig. 1, obtained through simulation is comparable with [6] as shown in Fig. 2. It was also observed that magnitude of peak impact force on rigid wall is in proportion to the weight of the motorcycles, i.e., 110 kg in the present study and 218 kg by [6]. It was concluded that the present M/C model can be used for further studies to estimate Δw and E_{def} of the M/C.

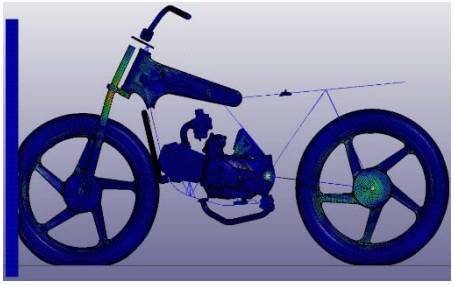

Fig. 1. FE model of typical 100 cc Indian M/C,

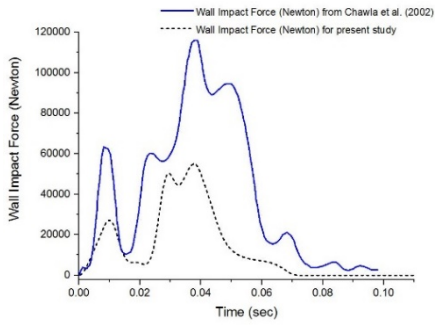

Fig. 2. Wall forces comparison for present study with [5]

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An FE model of a sedan car was adopted from the Centre for Collision Safety and Analysis (CCSA) library as PV [7]. One of the crash configurations was chosen for FE simulations from seven basic configurations recommended in [5]. In this study, 90 degree impact of the M/C against stationary PV was simulated using the Ls-Dyna^{TM} FE simulation package and relation between Δw of M/C and E_{def} of the M/C and PV at different Vimpact of M/C was analysed. A set of 10 simulations were analysed, with M/C velocity range from 3.6 km/h to 90 km/h impacting the front left side door of stationary PV.

III. INITIAL FINDINGS

From the simulation results of the M/C and PV impact, a reasonably linear relation between Δw and V_{impact} of M/C was obtained, as shown in Fig. 3. At speeds below 1 m/sec, it was observed that Δw was negligible. The parameter Δw measured in the simulations was the change in distance between the centres of the front and rear wheel of M/C FE model measured after impact with PV. A linear relation was also obtained between E_{def} and V_{impact} for both M/C and stationary PV, shown in Fig. 4. The simulation was carried out for 500 milliseconds which was enough for both the vehicles to come to rest after impact. Internal energy (IE) or work done in plastic deformation or E_{def}, of the deformed components of M/C and PV was obtained from simulation results. IE increased and reached a peak value with decrease in V_{impact} of M/C and reached a constant value when final velocity of both the M/C and PV reaches zero. The constant value of IE was taken as deformation energy corresponding to different speeds assigned to M/C to obtain data points for deformation energy corresponding to M/C and PV. The linear relationship obtained in this study is for a similar category or type of M/C, as presented in this study and for a speed range of 3.6 to 90 km/h for a 90 degree impact on the front door of a sedan type PV. Separate FE models for other categories of M/C based on different M/C structural and material properties are required. Similar study with different crash configurations, moving/stationary PV and impact locations (soft/hard or front/side/rear) on PV is also required and its development is planned.

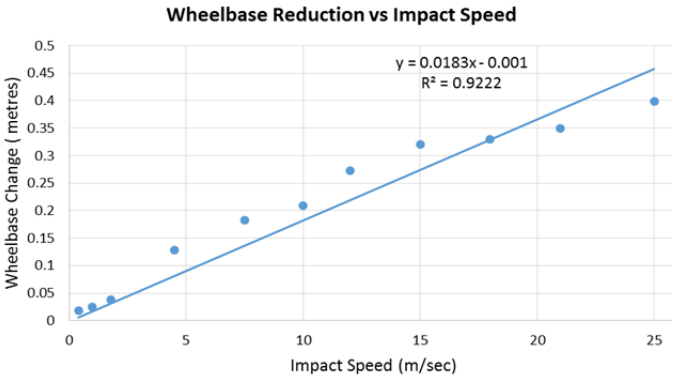

Fig. 3. Wheelbase reduction of M/C vs impact speed.

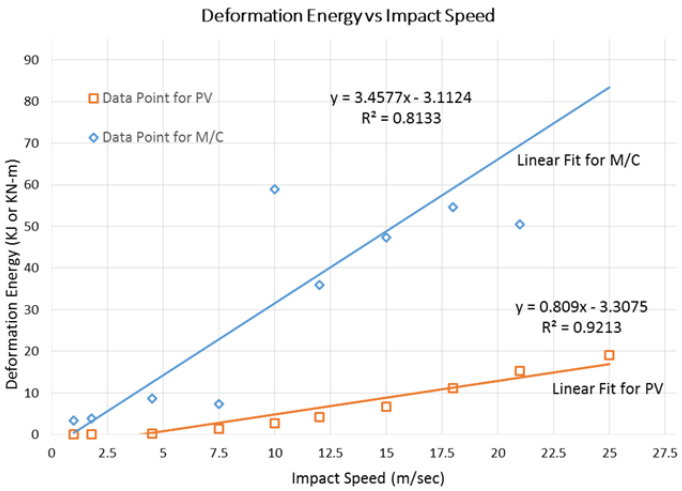

Fig. 4. Deformation energy vs Impact speed for M/C and PV

The FE simulation study and analysis results presented here mirror the response of full scale crash tests reported by various researchers [3-4] [8-9] for different classes of PTW not similar to Indian M/Cs.

IV. DISCUSSION

This study presents results for one configuration mentioned in [5]. This study was based on few PTW crashes (30) attended by a team on Indian roads. FE modelling and analysis of other crash configurations for PTWs, as mentioned in [5] need to be analysed using robust FE tools. Similar relation between Δw and V_{impact}, V_{impact} and E_{def} can be obtained for different categories of M/C and for different crash configurations. To improve the validity, component level impact test for major energy absorbing components are planned.

V. REFERENCES

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