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Evaluation of Vehicle Parameters Affecting Drivers Fatigue for Van Class Vehicle

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Abstract: **Each Vehicle is an assembly of almost 40 to 45 sub-systems like brakes, steering, seating, powertrain, exhaust, etc. When all these aggregates or sub-systems are sandwiched in to a Monocoque body shell (BIW) it forms a vehicle. Different type of vehicle is designed for different applications, Cars designed for Comfort & Safety whereas, commercial vehicles are designed for Load carrying capacities & durability. Vans are designed for all of these aspects and treated as MUV (Multi utility vehicles). Each vehicle with their own set of aggregates behaves differently to the driver's command. Vehicle (Vans in our case) reverts the reactions to drivers as per their design sophistication. Such a reactions subject the drivers physically & mentally. There are almost 2250 critical parameters, which need to be evaluated for each van class vehicle. All these vehicle parameters categorized into effort related parameters, Ambiance related parameters (Noise, Visionary field), Road induced vibration related parameters, Ergonomic parameters & Government regulations. Van design parameters must be within the limit, in order to ensure Driver's stresses & ultimately Driver's fatigue within the limits. As per the Company market survey Van class drivers are subjected to rough roads & higher speeds for Ambulance kind of application, whereas intermittent city people pickup for mini bus type of applications. Driver's Physical fatigue is the transient inability of a muscle to maintain optimal physical performance. This project is an attempt to evaluate most critical Van parameters, which directly affect the Driver's Physical & Psychological Fatigue.**

Keywords-- **Van, Fatigue, Steering Ratio, Driver's Field of Vision, Interior Noise, Engine mounts stiffness, Ground angles.**

I. INTRODUCTION

As soon as the cost effective commercial automobile production starts by Ford Motor Co., no of cars, Vans, Trucks, Trailers starts crowding the roads. Roads connecting the long distance cities get wider & more technical in construction. This all pushes the Automobile manufacturers to design and develop an automobile, which is safer, more comfortable, more stable & more predictable, at higher speeds. Current on road vehicles are more driver orientated. Today's drivers can able to perform many more functions, while driving. Automobiles (Cars, Vans & trucks) from today's world has an ability to do more than just driving. (Functions such as listening music, talking on mobiles, navigating the road map, controls the in vehicle temperature).

Design & development of an automobile is very complex process. Packaging of all sub-systems (Aggregates), their inter-relations behavior affects the total vehicle behavior in static & dynamic condition. In case of Vans (As manufactured in India) more than 2250 parameters need to be evaluated against the set targets. These parameters are the combinations of Safety aspects, government norms & OEM (Original equipment manufacturers) level targets based on experience & benchmarks. These parameters directly or indirectly affects the Driver & passengers stresses.

In this project, we will evaluate most critical parameters of a Van class vehicle, which affects the driver's Fatigue (loss of efficiency). Today's drivers is exposed to multiple controls at the same time, such as controlling music system, mobile devices, texting messages & mails, turning wipers & headlamps ON/OFF, Window glasses up/down, setting Air conditioner, etc. These tasks are additional to the routine driving function (Such multi features were not there in old automobiles).

We know that, as vehicle speed increases, drivers get minimal time to responds to the situations, therefore driving today's fast automobiles (Vans) need continuous attention on road, but practically these all things overload the driver physically & mentally. Such a functional overloading leads to rapid loss of driver's efficiency and results in Fatigue.

Driver's Physical fatigue is the transient inability of a muscle to achieve optimal physical performance, and mental fatigue is a transient decrease in maximal cognitive performance resulting from prolonged periods of cognitive activity. It can manifest as somnolence or direction attention fatigue. Medically, fatigue is a non-specific symptom, which means that it has many possible causes. Basically fatigue is taken as a symptom, rather than a sign because fatigue is a subjective feeling, rather than an objective one that can be measured. [1]

In the year of 2014, there were 864 fatalities recorded by NHTSA (National Highway Traffic Safety Administration Board, USA) related to Driver Fatigue. Such a fatalities remained largely across past decades. Between years 2005 to 2009, there was an estimated average of 83,000 crashes each year, which belongs to driver's fatigue & drowsy driving, this average includes most of 864 fatal crashes. In the year 2009, Massachusetts special commission on drowsy driving evaluation records death of 5000 peoples, due to driver fatigue, drowsiness & almost 5,00,000 injuries each year. [2]

For Indian Vehicle manufacturer's; Automotive Research Association of India, specifies the regulatory norms, which is nationwide published & provides the mandates/ Standards for vehicle level certifications. These standards are called AIS standards. They all are derived from IS, SAEJ, FMVSS & other worldwide automotive standards, which provide guidelines & restrictions to vehicle manufacturers, to design, develop a class of automobile (Car, Van, Pick-up, Trucks, Trailer, etc.), safer, durable & worthy to drive.

In this project we will evaluate the Van class (M2) vehicle against these regulatory norms, Vehicle level Performance Targets, Control efforts related targets, Visionary & Noise related targets set by Van Manufacturers (based on their expertise & Benchmarks data) in order to maintain maximum driver efficiency & to minimize fatigue.

II. LITRATURE REVIEW

Indian manufacturers evaluate the Van class vehicle for almost 2250 important parameters. These parameters are derived from Government regulations, International standards & company wide sets protocols or procedures & Benchmarking.

All Van class vehicle parameters are classified into 7 main categories, which are Parameters based on Driver Ambiance, Control efforts related parameters, Visionary Parameters, Noise parameters, Regulatory Parameters, Ergonomical (Anthropometric) parameters & performance parameters. Different Authors from different countries has evaluated the whole work of Human Machine Interface (HMI) according to these categories.

Author Kazimierz Jamroz & Leszek Smolarek explains Driver's fatigue in the International Journal of Occupational Safety & Ergonomics. Author's says Fatigue is usually defined as an internal condition leading to reduced ability to perform as a result of previous exertion. In the case of driver fatigue, an extended definition includes sleepiness, drowsiness, micronaps, reduced attention span and motivation to act, reduced alertness, degradation in performance and possibilities to make mistakes. Because of the complexity of the driver's situation, fatigue can be divided into the following types.

1. Muscular (physical) fatigue caused by static load and forced posture while driving.
2. Sensory fatigue leading to a reduced response of the senses as a result of long-term exposure to specific stimuli (light, sound, etc.).
3. Mental fatigue involving reduced cognitive capacity as a result of a shorter attention span and the monotony of driving (long trips, monotonous road environment, night-time, etc.)
4. Emotional fatigue is reduced response to situations (time pressure, conflicts with passengers, etc.) [3].

Author Onawumi, A. Samuel and Lucas and E. Babajide from Nigeria elaborate the Driver's work envelop. Driver's seating position, H-point position & space available for the driver must be properly defined, as per the vehicle type / Category in order to avoid discomfort such as backaches, strain, excess fatigue and extra stress on the neck and back. The cumulative effect of these discomfort is musculoskeletal disorder (MSD). Driver Comfort is associated with the short-term feel of seating while fatigue is associated with the long-term effects of driving. ISO 2631 explains that human body is most sensitive to seat vibrations between 4 and 8Hz. From the comfort aspects, provision for adjustments like seat adjustments, Steering wheel adjustment, and mirrors adjustment are vital for accommodating drivers of different sizes. Seat design is a crucial element of vehicle design & also a wide topic of research. Challenging task in scope of the ergonomics is the major differences in human capabilities with age, sex. Also, lack of 'world anthropometry database' puts enormous work to ergonomists and designers. [4]

Author Farshad Nadri, Mohammad Reza and team investigate Occupational Noise Exposure in Kerman Metropolitan Bus Drivers & explains their effect on driver, published in International Journal of Occupational Hygiene. Author explains that, the exposure to continuous noise above the 85 dBA may lead to hearing loss. The hearing loss is different from person to person and depends on the frequency of the noise and the time to exposure. This noises are sourced from Engine, Powertrain, Tyre roll, Wind cutting & continuous creaking due to loosening of riveted parts. Effect of high noise levels on hearing depends on factors such as noise pressure, exposure time, noise frequency, individual sensitivity, environmental condition and physiological factors. The frequency band of 500 kHz to 4000 kHz are interfering human speech and high noise levels in these frequencies interrupt communication [5].

All above authors & there research work it is clear that vehicle is a very complex system. Vehicle reacts to Driver, Passengers & to the objects inside the vehicle. These reactions affects Driver physically, psychologically, leads to Fatigue. Although fatigue is a subjective & varies person to person. Van manufacturers based on their research, benchmark & expertise, able to quantify the parameters & their limits, in order to minimize fatigue & fatigue based accidents.

III. VAN CLASS VEHICLE SPECIFICATIONS

We have selected a 15+D Van named as XX, whose baseline specification is as follows.

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Table 1
Van specification under evaluation & testing.

Sr.	Parameters	Values
7	Engine Power	85 Kw @ 3500 rpm
8	Engine Torque	290 Nm @ 1600 rpm
9	Clutch System	Single plate, Hydraulic.
10	Gear Shifting Mechanism	Cable operated.
11	Steering	Rack & Pinion type, Hydraulic
12	Brakes	Front Disc, Rear Drum type.
13	Front Suspension	Double wishbone with ARB.
14	Rear Suspension	Semi-elliptical leaf type.
15	Tyre Size	205/75 R16, Radial.
16	Fuel Capacity	70 Liters.
17	HVAC	Air conditioner with Demister.
18	Overall Length	5899 mm
19	Overall width	2359 mm
20	Overall Height	2490 mm (un laden)
21	Un laden Weight	2587 Kg
22	GVW (Gross Weight)	3937 Kg

As per above mentioned specifications, the selected Van is defined as M2 class, as per AIS-053, Amd-4, pp-12 and falls under Type-III, Mini bus, DCX (Deluxe) and ACX (Air conditioned Deluxe class), as per AIS-052, Amd-6. All regulatory norms mentioned by ARAI changes w.r.t these classes & parameters evaluation performed and presented in this article is applicable to above mentioned categories.

IV. Methidology

Practically, it is difficult to quantify the Fatigue by any engineering method. It is a subjective or person perspective. Van manufacturer's therefore iterated different vehicle parameters & studied their effects on different drivers & finally comes to the set of parameters called Targets. Each van to be designed, build & tested to meet these parameters to achieve maximum driver's efficiency, safety & durability within the market competitive cost.

V. Van Parameters Evaluation

Sr.	Parameters	Values
1	Model Name	TATA XX Van
2	Wheelbase	4078 mm
3	Configuration Type	Bus
4	Bus/ Ambulance/ Cargo	Bus
5	Seating Layout	15+D
6	Type of Drive	FWD

Following objective parameters are considered to be the most critical parameters, which directly affecting Driver's fatigue. Therefore they has to be evaluated to confirm within the targets according to the class of vehicle defined as mentioned in AIS standards.

Category-1 Control Efforts related parameters.

a) Steering control efforts.
b) Clutching efforts.
c) Gear shifter operation efforts.

Category-2 Driver's Ambiance (Visionary)

a) Headlamp projection field evaluation.
b) Driver's field of Vision evaluation.

Category-3 Noise & Vibration parameters

a) Interior Noise evaluation.
b) Engine mounts stiffness evaluation.

Category-4 Regulatory Parameters.

a) Evaluation of approach, ramp angles.

Category-1 Control Efforts related parameters

In case of any vehicle, most frequently acting controls are Steering, Clutch & Gear shifter.

In case of steering Following basic geometrical measurements were taken as a steering geometry definition.

Table 2
XX Van Steering geometry measurement

XX Van Steering Geometry (Un-laden)			
Sr.	**Parameters**	**Measured Results**	
		LH (Actual)	**RH (Actual)**
1	Camber	− 0°12'	− 0°10'
2	Caster	1°36'	1°53'
3	Toe (mm)	−0.8	−0.8
4	SAI	9°29'	9°10'
5	Thrust Angle	0°08'	
Front Wheel Lock angle Measurement			
Sr.	**Lock Angles**	**LH Turn**	**RH Turn**
1	Inner	41.5	41.5
2	Outer	36	34

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Van under evaluation has fully hydraulic Rack & Pinion type steering module is packaged. Most of the vans having GVW < 4 ton, prefers Rack and pinion type steering arrangement, due to its efficiency, lesser packaging space & lesser Maintenance. Some of the latest electric steering systems (Electronic Power Assist-EPAS) offers variable steering ratio at start & ends of steering movement.

We are now evaluating the steering ratio.

$$Steering\ Ratio = \frac{Angle\ turned\ by\ Front\ Wheels}{Angle\ applied\ to\ steering\ wheel}$$

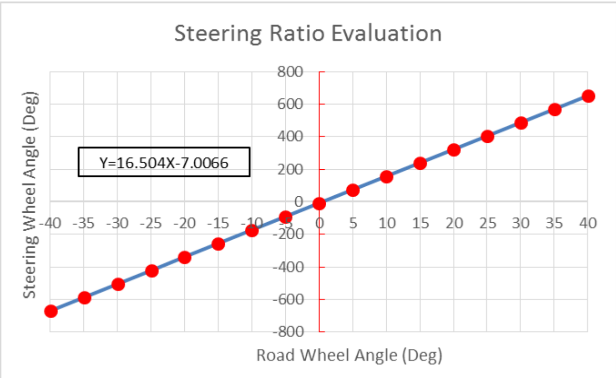

Fig. 1 Graph of Steering wheel angle vs Front wheel turning angle

From the above graph, measured Steering ratio is 16.5:1

Higher the steering ratio lesser the efforts driver required to turn the steering wheel, but too much steering ratio leads to more sensitive steering. Further, we have measured steering effort in Dynamic condition with Power-ON condition.

To negotiate a turn of 12 m radius Target requirement of Steering effort in Power-ON condition must be less than 15 Kg. (As per IS 11948:1999) Actual measurements are plotted in below graph.

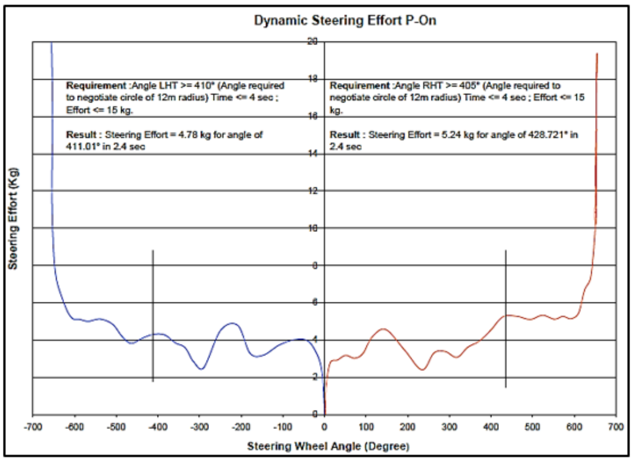

Fig. 2 Graph of Steering efforts (kg) vs Steering wheel Angle (Degrees)

From the above measurement, RHS and LHS side steering effort observed as 5.24 kg and 4.78 kg respectively, meets the IS 11948:1999 requirement of < 15 kg for M2 class Van.

Now second element is a clutch. In this case of XX Van, fully hydraulic type, concentric slave cylinder clutch mechanism is used. Clutch pedal effort is vital, as the Vans are used for intermittent Passenger pick-up application in case of Inter-city & Intra City applications & Ambulance applications. Refer below table for measured clutch effort vs clutch pedal travel against targets.

Table 3
XX Van Clutch parameter evaluation table

XX Van Clutch Efforts Evaluation				
Sr.	Test Parameters	Unit	Target	Actual
1	Clutch Pedal Travel	mm	-	150
2	Clutch Pedal Effort	Kg	< = 14	13.97
5	Clutch Grab		No	No

Graph shows the measurement of actual clutch effort vs pedal travel. Clutch efforts at max clutch travel is 3 Kg lesser than Peak clutch effort value as an observation.

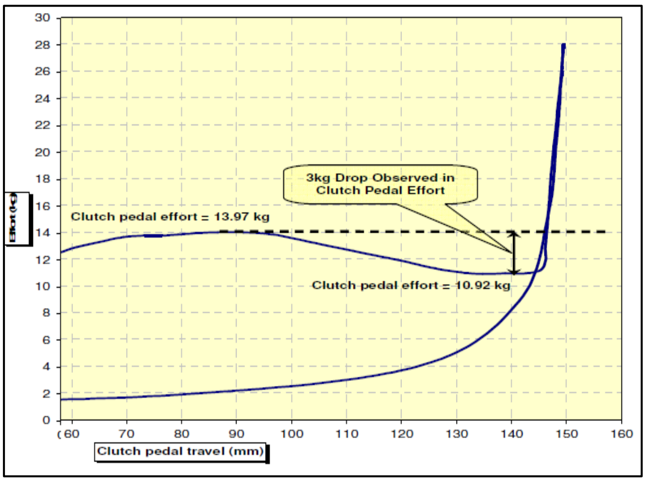

Fig. 3 Graph of Steering clutch pedal travel (mm) vs Pedal efforts (Kg).

Now the 3rd most important control element is Gear shifter. As per set target gear shifting effort required during upshift & downshift must be < 5 Kg.

Van under evaluation is having 6 FWD & 1REV type gear box with cable shifting mechanism. Following data was taken on High speed track, straight patch, during normal acceleration. Graph shows Gear lever shifting effort vs time.

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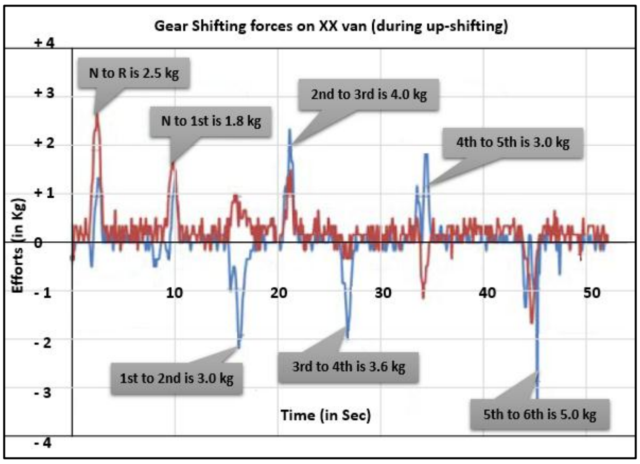

Fig. 4 Gear shifting efforts (kg) vs shifting time (in Sec)

From the above graph, we found that all gear shifts need efforts less than 4 Kg & for reverse shift (with Lift & shift) efforts recorded less than 1 Kg, therefore meets the Target value of < 5 Kg among all upshift & downshift.

Category-2 Driver's Ambiance (Visionary) Parameters.

Driver's field of vision is one of most critical parameter affecting driver fatigue. Specially driving in the night is more tedious. In this category we will evaluate Headlamp projection field & Driver's visibility through windscreen.

Headlamp position w.r.t ground is vital for light projection or focus projection distance. Below image shows the Headlamp distance from ground.

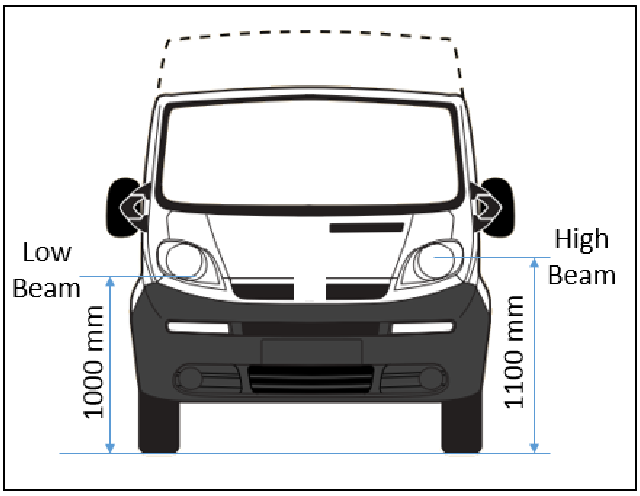

Fig. 5 Tata XX Van Headlamp Position w.r.t Ground

Test is performed on HST (High Speed Track, straight patch, on dark night). Light focus density band is captured (color plot with light spectrometer) in low beam condition for XX van as follows.

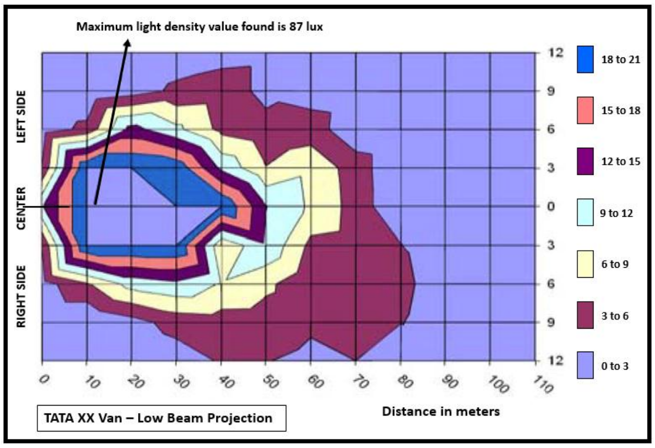

Fig. 6 Headlamp focus projection value vs distance plot

From focus density plot, new XX van headlamp illumination found better as focus range found 80 meters & spread is 12 meters. Max density of 87 Lux is recorded at central region. Excellent as compared to current vans in India.

Next is the evaluation of near field Vision. In this test, we evaluate the vehicle windscreen aperture design, which permits the driver to visualize maximum field area. Better visualization of surrounding offers less physical movement, Visual stress & fatigue. Evaluation takes place on 0.5 m grid flat ground. For visibility evaluation one object is taken which is identified as 1m tall, & object visibility is defined on 0 to 5 rating scale w.r.t. equivalent parts on the object. Total visible area is calculated based on the total numbers of visible markings on the object by checking object visibility in each block of the grid as shown in chart.

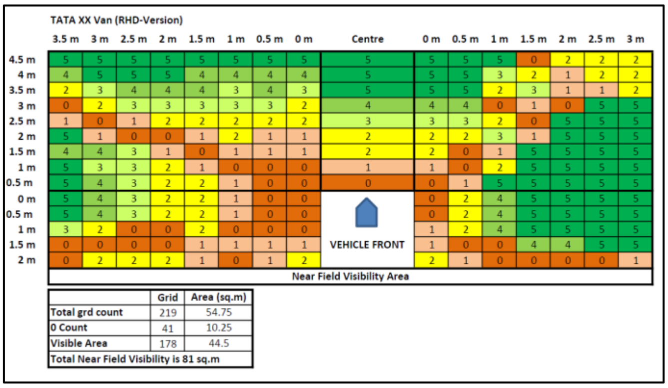

Fig. 7 Optical evaluation plot of Visual block visibility from driver position. (RHD)

From above plot we can able to conclude that Driver is sitting on RHD vehicle. Driver having an obstruction of A pillar on LH side causes poor visibility (marked more red blocks), whereas right side visibility is better. Total count of near field visibility of subject vehicle found 81m².

Parameters such as Driver H-Point (Driver's CG) position from ground, Windshield aperture, A-Pillar Section, Dashboard position, Headlamp position plays important roll to improve driver's field of vision. Minor flaws in these parameters put lot of strain to driver to know the vehicle position & to know the surrounding. Which leads to frequent driver movement & ultimately Fatigue.

Category-3 Interior Noise & Vibration Evaluation.

As per Indian regulations (As per AIS-020, pp-11) requirement noise level at Driver Ear level should not be more than 90dBA pressure, Considering background noise pressure < 10 dB(A).

There are 4 different sources of noise. 1st is from the engine & power train, 2nd is from tyre rolling, 3rd is from wind cutting through window cutout and the 4th is Air conditioning blower noise. Here we will evaluate Powertrain & Air condition blower noise @ Driver ear level and also at passenger ear level sitting at 3rd row (Middle row) and at 5th row (last row). Test conducted inside NVH (Noise, Vibration & Harshness) isolated chamber, where background noise < 5 dB (A). Vehicle engaged on dummy roller to simulate road rolling in gears.

Table 4
Sound pressure measurement at ear level in Idle and at different vehicle speed.

Sr.	Vehicle Condition (SPEED)	Sound Pressure level in dB(A)		
		DEL	ROW-3	ROW-5
1	IDLE	51.5	46.8	49.1
2	3G 40	62	61.3	63.8
3	4G 60	63.9	63.9	65.4
4	4G 80	67.3	65.8	67.2
5	5G 80	66.6	65.4	67.5
6	5G 100	70.5	69.4	71.2
G	represent gear position engaged.			
DEL	represent @ Driver ear level.			

Table 5
Sound pressure measurement at ear level with Air conditioning ON, Engine ON mode.

Ventilation Settings	Speed	Sound Pressure level in dB(A)		
		DEL	R-3	R-5
Front blower ON / AC ON / Chest Mode /Recirculated air	1	52	47.3	49.6
	2	57.5	51.2	53.3
	3	64.5	57.7	55.1
	4	73.9	66.8	64.1

From both the tables above, noise recorded by Microphones at Driver ear & at passenger ears found lower than 90 dB (A), meets AIS-020 regulatory requirements. Use of multilayer Acoustic materials will further help in sound isolation.

In case of automobiles, there is two sources of vibrations. 1st is vibration transmitted from Engine & driveline mounts to Vehicle Body and 2nd is road surface induced vibrations. Further we have evaluated the static stiffness of Engine Mounts. (Layer tyre rubber mounts with variable stiffness)

Table 6
Engine mount static stiffness measurement

Component	Compressive Load		
	Direction	Range (mm)	Stiffness (N/mm)
A mount	Z-Dir	1-6	185.8
	X Dir	1-10	62.6
B Mount	Z Dir	1-10	455.7
	X Dir	0.5-1.5	114.8
C Mount	X Dir	1-6	519.9

The Variation in static stiffness of each engine mount is a design logic. It is dependent on the total power train load distribution. Above information of stiffness clarifies that the CG of power train is more inclined towards B mount, due to north-south package of engine. Further C mount X-stiffness is intentionally kept on higher side, in order to minimize powertrain displacement during acceleration & Braking.

Category-4 Regulatory Parameters Evaluation.

Each vehicle rolled out, must be certified according to the applications to ply on Indian road. This is essential to ensure safety of the drivers & passengers. Different code explains dimensional constraints, space constraints, safety constraints & speed limits. AIS-052 popularly known as Bus Body Code provides the guideline for design of Vehicle interface.

When the Van approaches to the road bump, vehicle to ground angles came into picture. IS 12218:1987 clarifies the minimum ground clearance & ground angles requirement. Below image explains vehicle to ground angles.

A. *Approach Angle:* Angle between road horizontal to the front most (front of front wheels) bottom surface of Van.

B. *Ramp Angle:* Angle required to negotiate the bump without hitting.

C. *Departure Angle:* Angle between the road horizontal to the rearmost bottom surface of the van.

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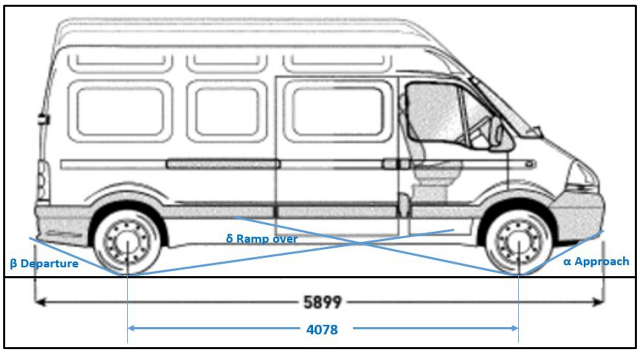

Fig. 8 Van ground angles evaluation.

Ground angles are measured w.r.t to the points of minimum ground clearance. This measurement is to be taken under rated Gross Vehicle weight. (3937 Kg) Ground clearance values depends upon the Tyre Size, Suspension stiffness and sizes of the parts packaged below the floor.

Achieving better ground angles is a designer's skill to package underbody parts in such a way that, it provide maximum ramp over angle. Underbody fuel tanks sometimes has metallic guard plate to protect from damages due to stone hitting & scuffing on speed breakers.

Refer below table (**Table: 7**) for lower most parts of van and their distance from ground. We have compared the same with existing panel van (Winger).

Table 7
Ground clearance at different underbody location.

Ground Clearance Measurement in Laden Case			
Sr.	**Location**	**Ground Clearance (mm)**	
		XX Van	**Winger**
1	Front Bumper	269	274
2	Gearbox	220	231
3	Rear Axle	175	170
4	Fuel Tank	240	215

Min Ground Clearance of 175 mm observed (in XX Van) in laden condition which is 5 mm higher than Benchmark Van (Winger).

Similarly Measurement of Ground angles are also taken for Van under evaluation & for market competitors as per IS 12218:1987, at rated load (GVW). Refer Figure 8 for ground angle positions.

Table 8
Ground Angles measured in at rated load

Angles in Degree	**Target**	**XX Van**	**Toyota Hiace**	**Winger**
Approach (α)	24	20	16	23
Ramp over (δ)	21	21	15	22
Departure (β)	17	14	18	20

The SUV category of vehicles normally have better ground angles than people movers. Therefore better Ground angles. Improvement in ground angle will leads to shift everything upside, which is not beneficial from CGz (Center of Gravity in vertical) point of view. Lower the CG height better the driving & handling, but chances of hitting road bumps will be more.

If the ground angles are on higher side, driver can able to drive the Van through off-road without much physical strain & therefore higher ground angles offers a fatigue free driving. Higher ground angles are essential for Ambulance type of van applications.

VI. CONCLUSIONS

Vans class vehicles provide car like comfort & offers loading capacity like a light commercial vehicle. Vans are popular for Ambulance, Mini Bus & Cargo kind of applications. Manufacturing a Van considering all these varieties are itself a complex process. Cost, Timeline & Service are commercial constraints, whereas Regulations, Performance & Safety are major design constraints.

Although all the parameters plays crucial role in fine tuning the Van designs. We have selected most critical parameters which are directly put the strain on driver & ultimately contributes to driver's Fatigue.

Fatigue itself a subjective parameter & varies person to person, based on his mental & physical state, environmental conditions etc. Based upon the years of research, Engineering & Govt. Regulations Van manufacturer's identifies the parameters which directly affecting the driver's Fatigue & their boundaries / targets.

This paper summarizes most critical parameters of M2 class van & evaluate a specific class of Van (as per AIS Van Classifications) against the set targets. Evaluation setup details and procedures are not elaborated, in order to keep focus on results & it's relationships with Driver's Fatigue.

Seating ergonomics & anthropometric parameters also plays the crucial role & has direct effect on comfort. These aspects are not considered / evaluated in the scope of work as it is a separate topic of research.

REFERENCES

[1] Marcora SM, Staiano W, Manning V. (January 2009), Mental fatigue impairs physical performance in humans, Journal of Applied Physiology, pp 857–864.

[2] Fatality Analysis Report (September 2014), National Highway Traffic Safety Administration, USA.

[3] Kazimierz Jamroz, Leszek Smolarek, (2013), Driver Fatigue and Road Safety on Poland's National Roads, International Journal of Occupational Safety & Ergonomics, Volume-19, pp 297-309.

[4] Onawumi, A. Samuel & Lucas Babajide, (April 2012), Ergonomic Investigation of Occupational Drivers and Seat Design of Taxicabs in Nigeria, APRN Journal of Science and Technology, pp 214.

International Journal of Recent Development in Engineering and Technology
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[5] Farshad Nadri, Mohammad Rezza Monazzam & team, (January 2012), An Invistigation on Occupational Noise Exposure in Kerman Metropolitan Bus Drivers, International Journal of Occupational Hygiene, Volume-4, pp 1-5.

[6] Dean F. Mengel, James Forbes & William Draper, (January 2010), Target Setting Principles and Methods in the Product Development Cycle, SAE International, Volume-3, pp 29-30.

[7] Alexandrino Filho, John L. Scholtes, Marcio Alfonso, Nat Jambulingam, (November 2002), Ford Product Creation Process, 11th International Mobility Technology Congress, Sao Paulo, Brazil, SAE International.

[8] AIS-052 Code of Practice for Bus Body Design and Approval, Amendment-6, pp 61-63.

[9] AIS-053 Automotive Vehicles Types-Terminology, Amendment-4, pp 11-12.

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