SAFETY IN COACH

IN CASE OF ACCIDENT OF A PASSENGER CARRYING TRAIN

Passengers Travelling
Inside the Coach

Should be SAFE
Minimize the Injury/Death

IN CASE OF ACCIDENT OF A PASSENGER CARRYING TRAIN

Injury/Death occurs
in the Accident due to

Fire

Derailment/Collision

CRASH/COLLISION VS FIRE

Contrary to Popular Thinking

Fire a Smaller Disaster – Slower Disaster

Derailment/Collisions Happen in

A Fraction of Second – No Escape.

Fire Happens Slowly

Giving a Few Minutes to Act and Escape

Crash is Followed by Relief

But, Fire can be Fought as It happens.

FIRE IN MOVING TRAINS

Significant Effects

- Destroys Completely in a Few Minutes
- Deaths or Incapacitation (Followed by Death)
  - Can happen in Two Minutes
- No External Rescue can be Arranged in This Period
- Even stopping a train takes longer than It takes Fire to Kill

WHAT MAKES FIRE ACCIDENT WORSE

Very Violent Propagation
Due to Wind and Open Coach

Moving Train – No Escape

Exit from Coach
Limited due to Overcrowding

Long Stopping Time

No Water Source Nearby

Often Far from Big Town and Roads
No Fire Brigade Help

FIRE AND ITS CONSEQUENCES

Asphyxiation

- Leading Cause of Death
  - by 3:1 ratio over burns

Generates

- Black Impenetrable Smoke (Toxic or not)
  - Blocks Vision and Stings the Eyes
    - Smoke Disorients People

STRATEGY FOR FIRE ACCIDENT

Prevention

Quick Detection

Suppression

Evacuation

ATTRIBUTES CAUSING INJURY/DEATH IN CASE OF ACCIDENT

- Fire
  - Spreading Fire Itself
  - High Temperature
  - Toxic Smoke from Burning
  - Poor Visibility due to Smoke
  - No Escape

FIRE ACCIDENTS

Evaluation of Risk

Risk	Value
Opacity	Visibility never under 4 m
Thermal risk	Temperature in air never over 66 °C Density of heat flux not over 2.5 kW/m²
Risk of anoxia	Concentration of oxygen never below 16 %
Toxic risk	Concentration of CO never over 1200 ppm

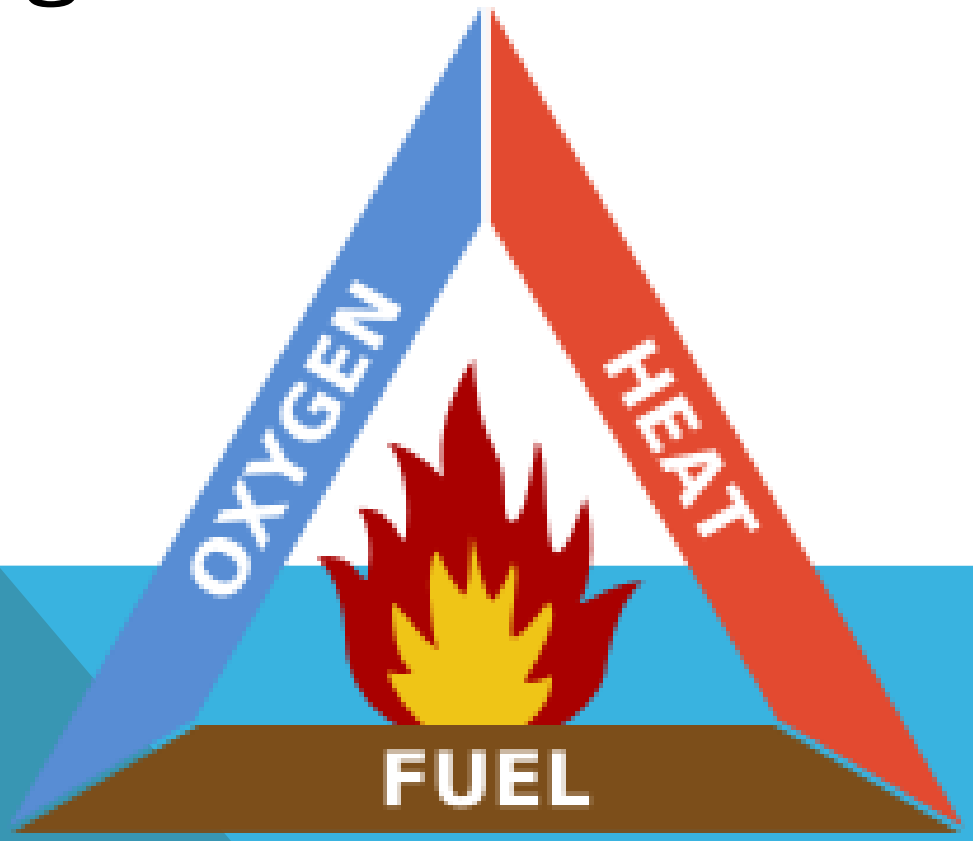
PREVENTION OF INJURY/DEATH DUE TO FIRE

Upgradation of Coach Furnishing Material for

- Fire Retardation
- Arrest Toxicity of Smoke
- Reduce Thick Smoke
- To withstand at High Temperature
  - Should not Melt/Drop
  - Char Formation
- Controlled Heat Release

OBJECTIVE OF FIRE RETARDENT

Fire Triangle



OBJECTIVE OF FIRE RETARDENT

- Burn Slowly
- Take Longer Time
  - For Evacuation of Passengers
  - For Taking Action for Fire Fighting
- Property of Self Extinguishing
  - When Ignition Source Removed

WHY FIRE RETARDATION

5 Stages of Fire

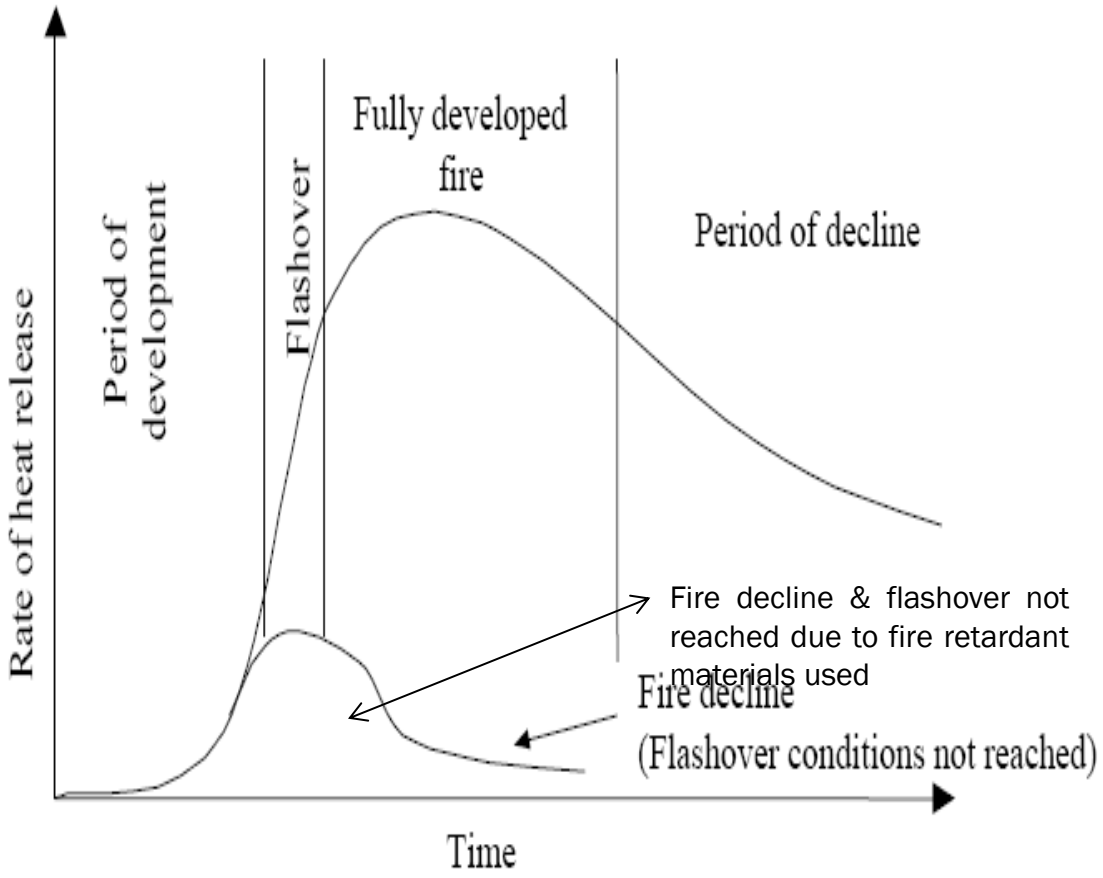
Ignition

Growth

Flashover

Fully developed fire

Decline



Fire Retardant Material Delay Flashover

FLASHOVER

Flashover

- Near-simultaneous Ignition of
  - Directly Exposed Combustible Material
  - Certain Organic Materials on Heating
    - Undergo Thermal Decomposition
      - Release Flammable Gases
  - Temperature Driven Event

After Flashover

- Fire in fully Developed Stage
- Heat Release Rate at Maximum

RDSO STUDIED

The Coach Furnishing Materials to

Improve Fire Retardant Property
Reduce the Toxicity after Burning
Reduce the Thick Smoke
Minimize Maximum Heat Release Rate

And Specifications were made

SPECIFICATIONS

Resistance to Spread of Flame

Class A of Applicable Appendices of UIC-564-2 OR

Limiting Oxygen Index

Min 35 as per IS: 13501 or IS:13360

Low or Light Smoke

Class A or B of Appendix 15 of UIC-564-2 OR

Toxicity after Burning

<1 as per NCD 1409

Maximum Heat Release

EN 45545-2:2013

THEORY OF FIRE RETARDENT

- Fire Retardant Material
  - Promote Endothermic Reaction
  - Forming Protective Layer
  - Releasing Water or Carbon Dioxide
  - Char Formation
  - By adding
    - Aluminum or Magnesium Hydroxide
      - Releases Water on Heating
      - Makes Protective Layers Alumina MgO
    - Char Formation
      - Much Harder to Burn

LIMITING OXYGEN INDEX

Percentage of Oxygen in Air Required

To Maintain Fire Propagation

In Test Specimen

The value of index

((Oxygen/(Oxygen+Nitrogen)x100))

Specimen Supports

Candle Like Burning

CRETERIA LOW SMOKE

Measurement of Deterioration in Visibility Due to Smoke By Passing Light of 100 Lux

E_4 (Lx) $T_{(lx\ min)}$	$E_4 \geq 50$	$20 \leq E_4 \geq 50$	$E_4 < 20$
$T \geq 300$	A	B	B
$150 \leq T, 300$	B	B	C
$T < 150$	C	C	C

E4 – Intensity of Light after 4 min. (Lux)

T – Area of Intensity vs Time Graph (Lux-Min)

Important for Evacuation of Passengers

TOXICITY

Measured after Heating of Specimen at 1200ºC

- Collection of Gases
- Analysis of Gases Collected
  - Mandated Less than 1 of NCD 1409

- Toxicity Level < 1 of NCD 1409
  - Permit 25-30 min for Safe Evacuation

TOXICITY

(As per NCD 1409)

SN	Name of the Gas	Toxicity concentrations in ppm
1	Carbon Dioxide (CO_2)	100000
2	Carbon Monoxide (CO)	4000
3	Hydrogen Fluoride (HF)	100
4	Hydrogen chloride (HCl)	500
5	Hydrogen Bromide (HBr)	150
6	Hydrogen Cyanide (HCN)	150
7	Nitrogen Oxide (NO, NO_2)	250
8	Sulphur Dioxide (SO_2)	400
9	Formaldehyde (HCHO)	500
10	Ammonia (NH_3)	750
11	Acrylonitrile (CH_2CHCN)	400
12	Hydrogen Sulphide (H_2S)	750
13	Phenol (C_6H_5OH)	250
14	Phosgene ($COCl_2$)	25

CONTROLLED HEAT RELEASE

Heat Released is determined with

- Cone Calorimeter Test as per ISO 5660
- Calculation of Parameter
  - Heat Released
  - Maximum Heat Released
  - Time to reach Maximum

FOLLOWING ITEMS SPECIFICATION UPGRADAD BY RDSO

Wood Based Impregnated Compressed Laminates

Fire Retardant Upholstery

Fire Retardant Curtains

FRP Doors of Coaches

Modular Toilets

Natural Fiber Thermoset Composite Sheet for Roof Panelling

FOLLOWING ITEMS SPECIFICATION UPGRADAD BY RDSO (Contd…)

Pre-laminated Shaded Compreg

Decorative Thermosetting Synthetic Resin Bonded Laminated Sheet

Non-asbestos Limpet Sheet for Roof Ceiling Flexible Vinyl Flooring

Densified Thermal Bonded Polyester Blocks for Seats and Berths

Vinyl Coated Upholstery Fabric for Seat and Berth

FOLLOWING ITEMS SPECIFICATION UPGRADAD BY RDSO (Contd…)

Sheet Molding Compound for FRP Product

Fiber Glass Reinforced Plastic Window

Sheet Molding Compound Window Guide, Sills and Cross Members

Flexible Load Bearing Polyurethane Foam Cushion

UIC Type Elastomer Flange Connection Vestibule

DEVELOPMENT OF FIRE BARRIER IN LHB COACHES

Fire Barrier in End Vestibule Door

Door will be closed as Temperature rises

Sealed by Mastic Sealing

Prevents Passengers rushing towards Fire affected coach

QUICK DETECTION

Very Early Smoke and Fire Detection System

RDSO/2008/CG-04 (Rev.-3)	STR for Aspiration Type Automatic Smoke Fire detection with Alarm System for AC Coaches (EOG)
RDSO/2013/CG-06	STR for Automatic Smoke Fire detection cum Manual Suppression System for Pantry Car & Power Car (ICF and LHB Design)

ASPIRATION TYPE AUTOMATIC SMOKE FIRE DETECTION WITH ALARM SYSTEM FOR AC COACHES (EOG)

Capable of Early Warning
Detection System in Coach Communicating
with Centralized Control Panel
Draws Air Sample from
Monitored Environment
Through Aspirator Network
Heat Detection Units
Installed in
Humsafar Coach JAT Rajdhani

ASPIRATION TYPE AUTOMATIC SMOKE FIRE DETECTION WITH ALARM SYSTEM FOR AC COACHES (EOG)

- Working Principle
  - Capturing Air Samples by Creating Suction
  - Filtering of Dust to avoid False Alarm
  - Highly Sensitive Laser Detection Unit
  - Nephelometer
    - Check by Light Scattered by
      - Smoke Particle
  - Can Detect Smoke before being Visible

Aspiration Type Automatic Smoke Fire detection with Alarm System

	Threshold Settings for						
	AC Coaches		Pantry Car			Power Car	
Alarm	Threshold (% obs/m)	Delay Period (Sec.)	Threshold (% obs/m)		Delay Period (Sec.)	Threshold (% obs/m)	Delay Period (Sec.)
			Day	Night			
Alert	0.35	20	1.0	0.35	30	0.5	45
Action	0.6	30	1.2	0.6	30	0.8	30
Fire-1	1.6	45	1.8	1.6	45	1.6	45
Fire-2	3.0	10	3.0	3.0	10	3.0	10

Aspiration Type Automatic Smoke Fire detection with Alarm System for AC Coaches (EOG)

Four Level Alarm

Alert –	No Signal in Coach Visual Signal at CMS
Action –	Audio Visual Signal at CMS Flasher at Coach
Fire 1 –	Automatic Brake Application Hooter after delay of 55 Sec.

Automatic Smoke Fire detection with Alarm & Suppression System for Pantry Car/Power Car

- Fire/Smoke Detection Sensors
- Heat Detection Sensors
- Fire Suppression System
  - Water Mist Fire Fighting Equipment
  - Operation of Lever Manually
  - Cylinders of 50 Ltrs
    - Containing 33 Ltrs Water
    - Nitrogen Gas for Pressurizing

Automatic Smoke Fire detection with Alarm & Suppression System for Pantry Car/Power Car

- Alarm
  - In Pantry Car Manager Room
  - In Escorting Staff Room
- Physically Checking
- Switching Off Electrical Equipment
- Releasing of Lever Manually
  - of Fire Suppression System

EVACUATION

Fluorescent Signage

Visible even in Low Light

Emergency Exit Windows

AC coaches 1220MM x 610MM

Non-AC coaches 590 MMx610MM

S. No.	Type of Coach	No. of Emergency Exit/ Emergency Windows
1.	GS Coach	4
2.	SCN coach	4
3.	ACCN coach	4
4.	ACCW coach	4
5.	FAC	all coupe

ATTRIBUTES CAUSING INJURY/DEATH IN CASE OF ACCIDENT (Contd…)

- Derailment/Collision
  - Impact
  - Hitting by Internal Fittings
  - No Escape in case of Capsize
  - Climbing of Coach over Other

ATTEMPT TO REDUCE INJURY/DEATH IN CASE OF DERAILMENT/COLLISION

Reduction in Impact

Anti-Climbing Feature

Injury Free Fittings

Provision to Escape

ATTEMPT TO REDUCE INJURY/DEATH IN CASE OF DERAILMENT (Contd…)

Crashworthiness

Ability of Structure to Protect Its Occupants during Impact

Body Structure Includes Progressive Crush Zones to Absorb Crash Kinetic Energy

CRASHWORTHINESS - OBJECTIVES

No Deformation in Passenger Occupied Areas

No Climbing of Coaches one over the Other

Energy Absorption in Non-Passenger Areas

Controlled and Progressive Collapse of Coach Structure

Low Decelerations

To avoid Injuries to Occupants Due to Secondary Impacts (Impact with Coach Interiors)

CRASHWORTHY DESIGN

Absorb Collision Energy in
    Controlled and Predictive Manner
Reduce the Risk of Over-riding
Maintain
    Survival Space and
    Structural Integrity of Occupied Areas
Limit the Deceleration
Reduce the Risk of Derailment

CRASHWORTHY DESIGN

GENERAL PRINCIPLES EN 15227

Coaches defined as Category C1

To be tested for Collision Scenarios with Identical Train Unit at Collision Speed of 36 kmph

Mean Longitudinal Deceleration to be Limited to 5g to 7.5g

CRASHWORTHY DESIGN ON IR

RDSO took up the Exercise of

Crashworthy Coach Design in 2004

RITES along with

M/s Transportation Technology Center

Applied Research Associates, (ARA)

helped establish

Crashworthy Coach Design Centre

CRASHWORTHINESS

Crash Test of Modified Coach LHB

- Done at RDSO at Speed 43.2 kmph against Concrete Wall Loaded Wagon
- Coach Absorbed Energy without Affecting Passenger Area
- Crash Test of Modified ICF Coach was done in 2006 and was Successful

CRASHWORTHINESS (Contd…)

Crash Test of Coach LHB

- Coach has Crumble Zone in Both end to Absorb Energy
- Achieved by Provision of Honeycomb Structure as Primary Shock Absorber
- Honeycomb Structure Provided Behind Backstop of CBC

CRASHWORTHINESS (Contd…)

Modification Done for Making Crashworthy

- Incorporation of Sacrificial Elements
  - Located away from Passenger Area
- Provision of H Type CBC
  - Prevent Uncoupling
  - Directing the Force to Couplers
  - Anti Climbing Feature
- Honeycomb Structure between
  - CBC Rear Stop & Body Bolster
- Buckle Initiator with Elongated Hole
  - Behind Draft Gear

CRASHWORTHINESS (Contd…)

Modification Done for Making Crashworthy

Extension of Centre Sill upto Body Bolster
To Accommodate Honeycomb
Strengthening of Door Cut Out & Doorway
To Prevent Collapsing of Door
Top Plate 6 mm Replaced by
4 mm Plate in Lavatory
2 mm Plate Beside Centre Sill

CRASHWORTHINESS (Contd...)

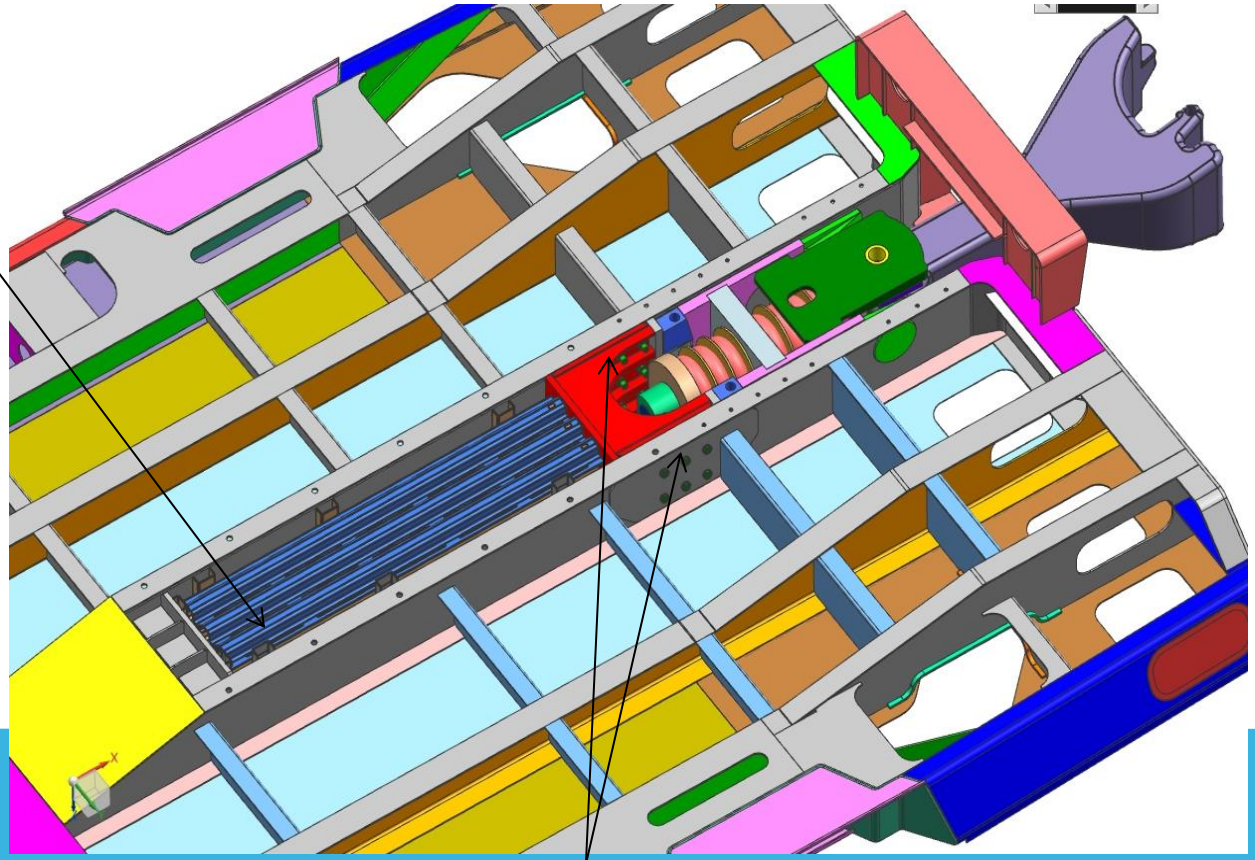
Working of Honeycomb Mechanism

At Force of 2000 KN at Coupler
Backstop Bolt will be snapped
Coupler Mechanism will act as Ram
Against Honeycomb
Plastic Deformation of Honeycomb
Gradual Absorption of Crash Energy

Illustration1 Illustration2

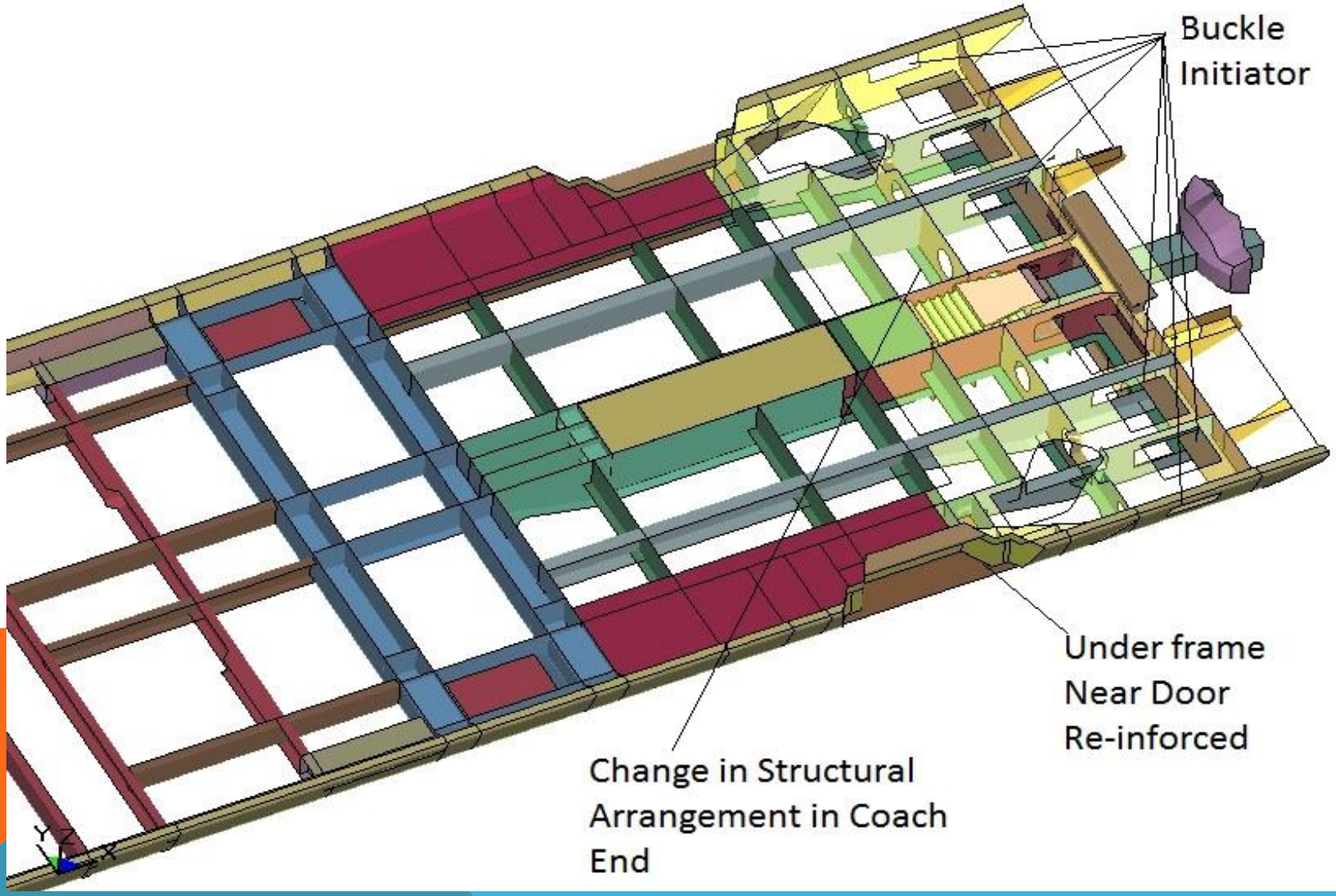
Modelling of LHB Coach for Crash Simulation

Primary Energy Absorber (Honeycomb)



Shear back arrangement (rear stopper + shear bolts)

Modelling of LHB coach for crash simulation



PRIMARY ENERGY ABSORBER (HONEYCOMB)

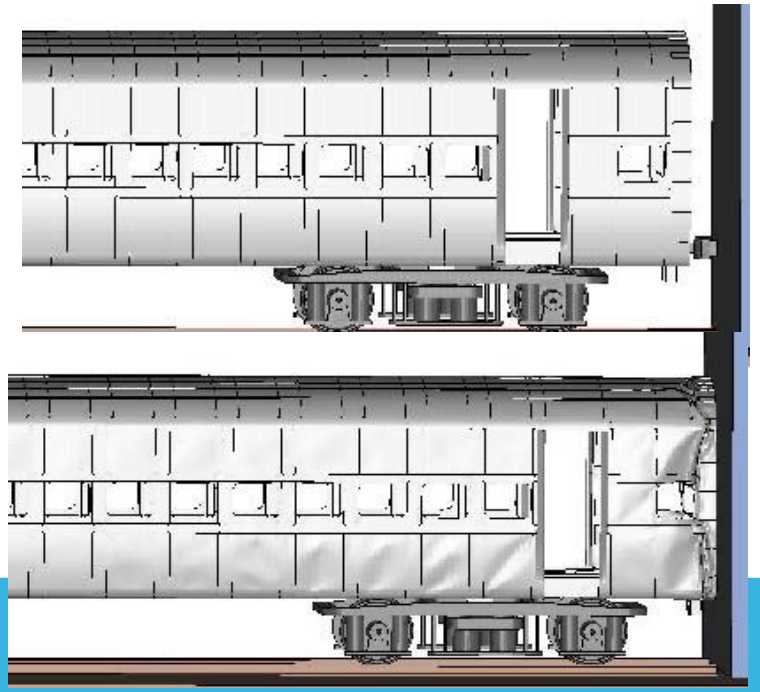
Steel Honeycomb
(Indigenous)

Aluminium Honeycomb
(Imported)

CRASHWORTHY DESIGN METHODOLOGY

Crash Simulations of ICF GS Coach

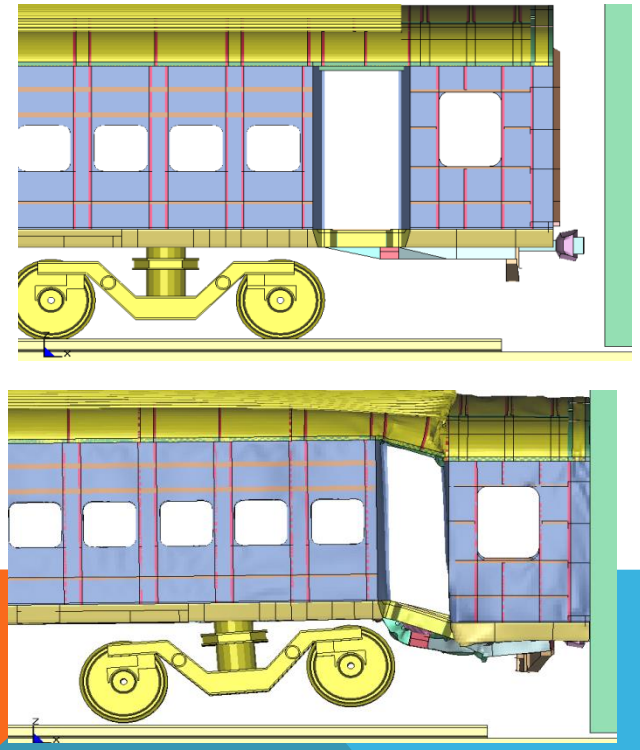
Baseline GS coach crush behavior with side buffers.



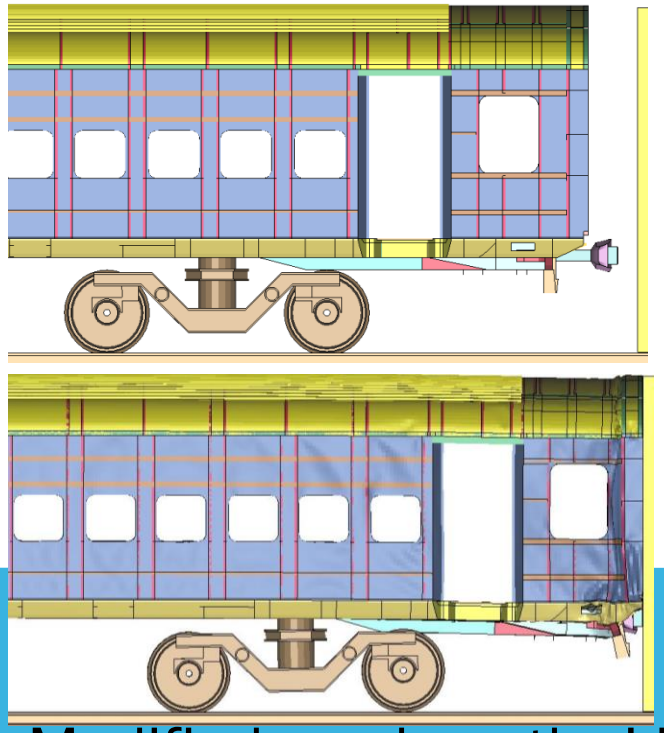
Modified crashworthy GS coach crash behavior.

CRASHWORTHY DESIGN METHODOLOGY

Crash Simulations of LHB GS Coach



Baseline LHB GS coach crush behavior.



Modified crashworthy LHB GS coach crash behavior.

CRASHWORTHY DESIGN

Platen Car Ramp Test LHB GS Coach

H-TYPE COUPLER TO PREVENT CLIMBING OF COACH OVER ANOTHER

CRASHWORTHINESS (Contd…)

Crash Test of Modified Coach LHB

Done at RDSO at Speed 43.2 kmph

against Concrete Wall Loaded Wagon

Energy Developed during Collision - 2.4 MJ

Energy Absorbed by Draft Gear - 45 KJ

Energy Absorbed by Rear Stop - 41 KJ

Energy Absorbed by Primary Absorber - 720 KJ

Energy Absorbed by Secondary Absorber - 470 KJ

Total Energy Absorbed - 1.2 MJ

Kinetic Energy of Combined Coach & Wagon – 0.6 KJ

Remaining Energy to be Absorbed by Coach - 0.6 MJ

ATTEMPT TO REDUCE INJURY/DEATH IN CASE OF DERAILMENT (Contd…)

- Injury Free Fittings
  - Flush in Type Reading Light
  - Handles Ladders Covered with Foam
  - Foldable Ladder in First AC
  - Sharp Edge of Seats Berths Rounded
  - Flush in Type Snack Tray

BEFORE

Fixed type coat hook on Lavatory doors

AFTER Swivel type coat hook on lavatory door

Before Protruding soap tray with sharp corners

After

Sunk in Stainless steel mirror shelf

Before

Projecting type handles on Water Tank arch

After

Folding type handles on Water Tank arch

Before

Fixed type coat hook on compartment partition

After

Swivel type coat hook on compartment partition

Head rest for upper berth at head side

PU Foam moulded safety railing for upper berth

Before Metal Ladder for climbing upper berth

After

PU Foam moulded Ladder for climbing upper berth

After Tertype latch for single seat back rest

BEFORE -Projecting Button type latch design

Before

Single seat retaining bracket

Now

Pin type latch for single seat back rest

ICF SR CN 04288

Before Metal Suspension strap (sharp corners) without PU foam coating for upper Berth

Suspension strap with PU foam coating for Upper Berth

After

Before

Wire rope for luggage locking on lower berth

After

Foldable rings for luggage locking on lower berth

Before GS, SLR Luggage rack without additional pipe

After Applicable for Production units only

GS, SLR Luggage rack with additional pipe

Provision of PU Foam cushion on sharp corners of non - rounded berths

Before -

BANJO Metal Shutter Frame with inside Projection in Lavatories of Non AC Coaches.

After- Projecting type Metal frame Banjo shutter arrangement on Non AC lavatory to be replaced by providing rubber sealed window glass as in AC Coaches along with exhaust fan arrangement

Rubber sealed window glass

Exhaust fan arrangement

ATTEMPT TO REDUCE INJURY/DEATH IN CASE OF DERAILMENT (Contd…)

Provision to Escape

Provision of Fluorescent Signage
Quick Identification

Provision of Emergency Window

Removal of Bottom Latch of Doors

EMERGENCY EXITS

Emergency Windows of Size

AC coaches - 1220MM x 610MM

Non-AC coaches - 590 MMx610MM

S. No.	Type of Coach	No. of Emergency Exit/ Emergency Windows
1.	GS Coach	4
2.	SCN coach	4
3.	ACCN coach	4
4.	ACCW coach	4
5.	FAC	all coupe