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THE ONLY PRODUCER OF



**HARDOX®**  
WEAR PLATE

**WEBINAR: 27/07/2021**

# **HOW TO UPGRADE YOUR TIPPER BODY DESIGN USING HIGH STRENGTH STEEL**

**SSAB TECH SUPPORT :  
RAMANUJAM SARAVANAN**

**KNOWLEDGE  
AND SUPPORT  
FOR YOUR  
APPLICATIONS**



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# About the speaker

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Technical Development Manager - Heavy Duty Transport Segment  
SSAB Special Steel Division  
*India, Sri-Lanka, Nepal, Bangladesh & Bhutan*

- Bachelor in Automobile Engineering
- Masters in Business Administration (Technology Management)
- 24 Years of Commercial Vehicle Body Design experience from Major Truck OEMs/Vehicle Body Building Industries in India & Middle East.

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**AT YOUR  
SERVICE 24/7**

SSAB Vision

**A stronger, lighter and more sustainable world.**

Together with our customers, we will go further than anyone else in realizing the full potential of lighter, stronger and more durable steel products.



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## DESIGN TIPS & IDEAS



## LIGHT WEIGHT TIPPER

# 1. Use of High Strength Steel in CV Body Building Industry



- In 1996, first half-pipe Hardox body from SSAB was worked out & tested.
- In 1998 this type of body was displayed in IAA Hanover, Germany.



- Almost all the Mining Tippers are made up of Hardox Materials in India.
- Due to strict overloading restrictions & more weight savings, Hardox is popular nowadays.

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## 2. What is High Strength Steel?

► High Strength Steel is also a steel which has the same Density and Young's modulus similar to Mild Steel.

HIGH HARDNESS

HIGH TENSILE STRENGTH

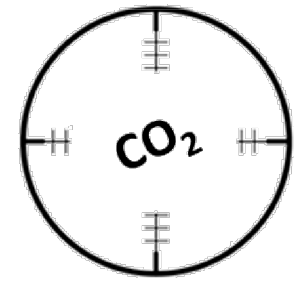
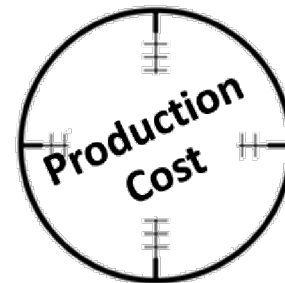
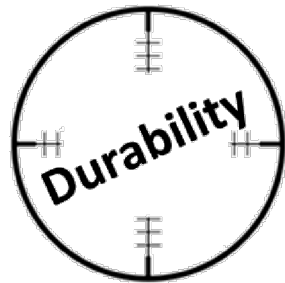
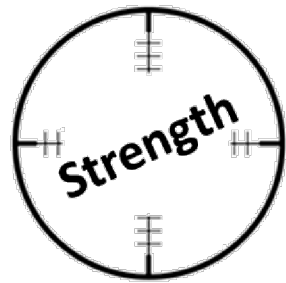
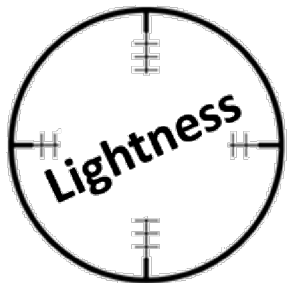
HIGH YIELD STRENGTH

HIGH IMPACT TOUGHNESS

HARDOX <sup>®</sup> 450 Vs BSK 46 – COMPARISON KEY PROPERTIES	Hardox 450	BSK 46 (IS: 5986)
Hardness – BHN Nominal	450 (425-475)	163 (Max)
Yield strength (Mpa) (* Approximate Value)	1250 Mpa (*)	460-560
Ultimate Tensile Strength	1400 - 1425	500-640
Impact Toughness : Longitudinal test, typical impact energy, Charpy V 10 x 10 mm test specimen. Toughness means ability to resist crack propagation (withstand a crack). Most steels have lower toughness at lower temperatures.	50 J at -40°C	25 J to 30 J at -26°C to 28 °C

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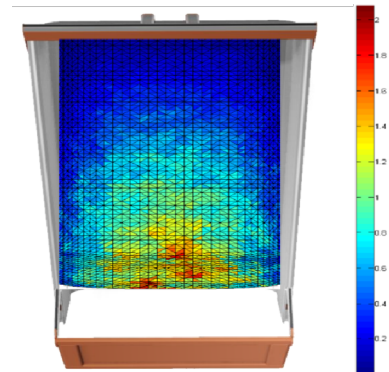
### 3. Advantages of SSAB High Strength Steels



- ✓ When the weight of the vehicle is lower, the fuel consumption reduced.
- ✓ Rule of thumb = 1 ton self weight reduction in a 60 ton trucks reduces fuel consumption by 1% when driving empty.
- ✓ Lower fuel consumption results,
  - In lower operating costs
  - Increasing competitiveness
  - And lower Co<sub>2</sub> emissions



**Less Fuel Consumption**



**Wear & Dent Resistant**

## 4. Why should I upgrade?

- ▶ Either to increase the payload on the existing structure
- ▶ or to make the whole structure lighter & resist higher payload,
- ▶ or to increase the safety margin to overloading.
- ▶ or reduce body maintenance intervals.

## 5. Benefits of upgrading

### ► Tipper Body Manufacturers

- Modular Product Solutions
- High Production Efficiency
- Easy handling due to light weight

**-200 000**  
tonne reduced CO<sub>2</sub>  
emissions from  
upstream suppliers

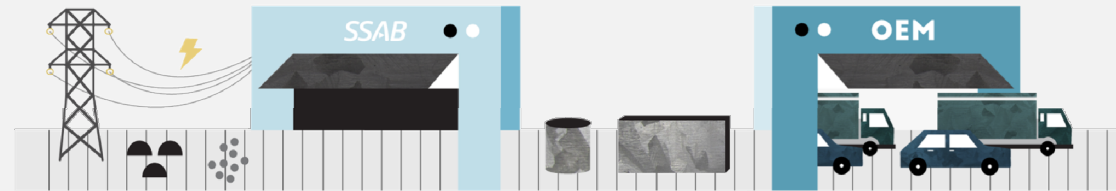
**-500 000**  
tonne reduced CO<sub>2</sub> emissions  
from steel production

**-7 300 000**  
tonne reduced CO<sub>2</sub> emissions  
during use-phase

**-8 000 000**  
tonne total reduced  
CO<sub>2</sub> emissions

### ► End users

- High payload
- Less fuel consumption
- Less Maintenance
- Quick ROI



### ► Environment

- Less steel consumption
- Less fuel consumption
- Less Co<sub>2</sub> emission

**Upgrading** to higher strength results in **weight savings**. Less steel needs to be produced and less resources are needed.

**90%** of the reduced environmental impact can be related to the **use-phase** of lighter vehicles, through reduced fuel consumption.

**Large CO<sub>2</sub> savings** are possible when utilizing and upgrading to high-strength steels.

Source: Jernkontoret, the environmental research program "the steel eco-cycle", calculated out of the average life span among European vehicle fleet.

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**6. Do I need to change my present Tipper Body Design ?**

## 6. Do I need to change my present Tipper Body Design ?

There are many aspects to take in consideration but these are the three main design challenges to remember when upgrading.

### 1. STIFFNESS 2. BUCKLING 3. FATIGUE

**Stiffness** : is to resist elastic deformation.

eg. A Square Hollow Section is stiffer than circular beam.



**Buckling** : is the sudden change in shape of a structural component under load.

eg: Bow of a column under compression (or) the wrinkling of a plate under shear.

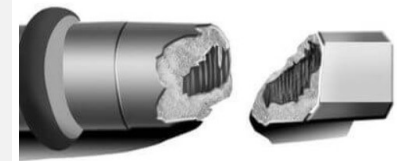
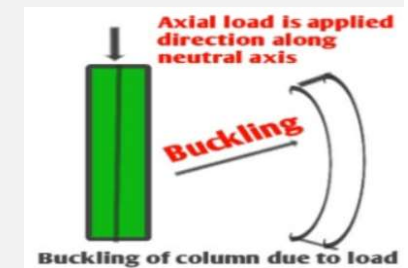
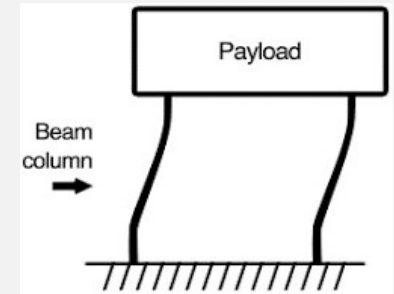


**Fatigue** : is the weakening of a material caused by cyclic loads.

It generally involves gradual growth of cracks & ultimately lead to fracture.



Based on these above 3 design considerations you might have to change your existing design.



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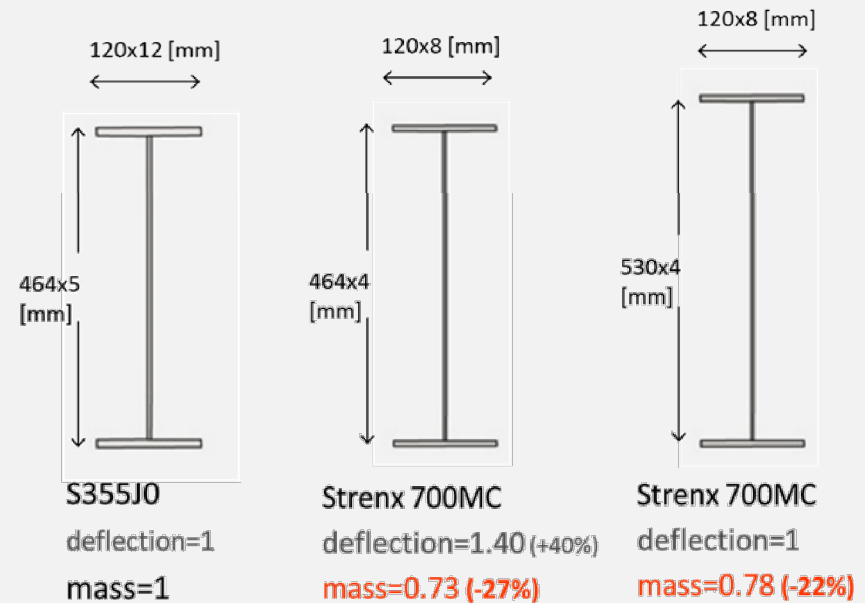
## **7. In what way do I need to change my present Tipper Design ?**

# 7. In what way do I need to change my present Tipper Design ?

## 6a. Stiffness

- ✓ Upgrading means inducing higher stress in the whole structure due to lesser plate thickness.
- ✓ Lighter structure carrying the same load will have more deflection.
- ✓ E.g Change the geometry, the height of an Main beam for instance

*Upgrading example of I-beams. Same Bending Moment Resistance*

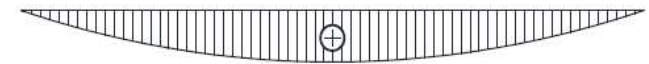
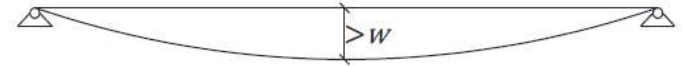
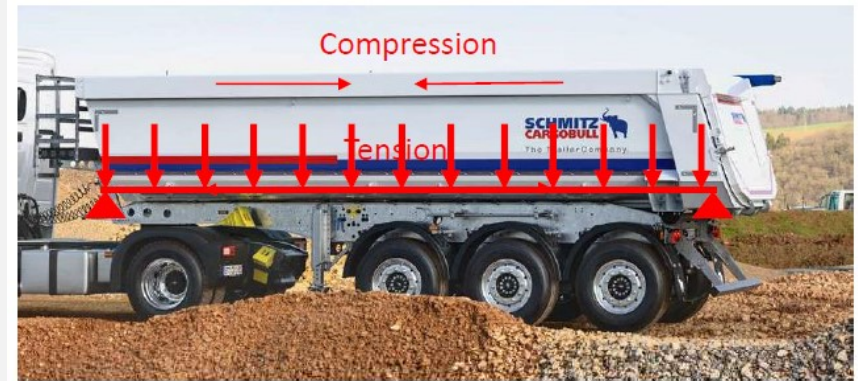
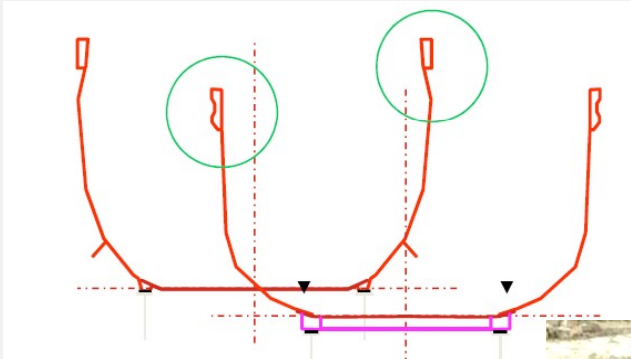


Details are in SSAB Design Handbook.  
Learn more at <https://www.ssab.com/support>

## 7. In what way do I need to change my present Tipper Design ?

**6b. Buckling :** - Critical for compressed parts with large free areas.

- Add a bend (or) increase the number of bends is the solution.
- E.g Top rails with one or two additional bends.

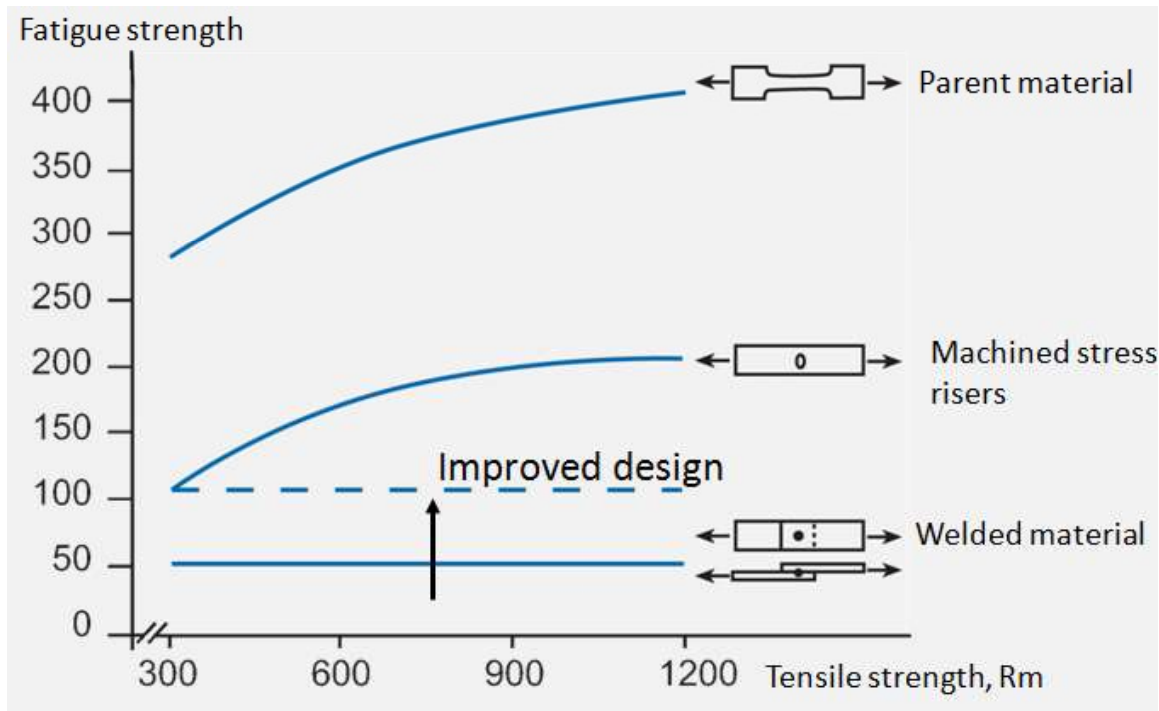


*Upgrading example of Tipper Body Top Rails*

## 7. In what way do I need to change my present Tipper Design ?

**6c. Fatigue** is the weakening of a material caused by cyclic loads.

A weld means that you already induced” a crack in the parent material”.



**Fatigue strength of a material can be improved by :**

- Move the welds to low-stress areas
- Good geometry
- Improve weld quality
- Size of undercut
- Weld angle
- Weld toe radius
- Maintain Throat Thickness
- Weld penetration
- Puddle Welds

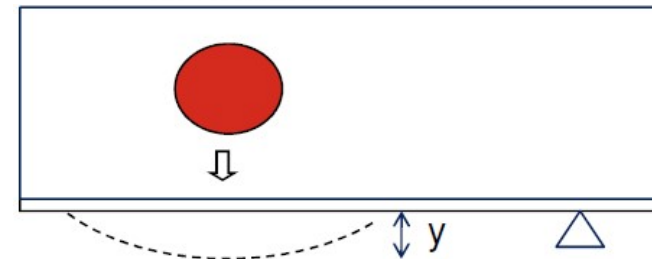
## 8. Important Design Aspects to consider

## 8. Important Design Aspects to consider

### STIFF BOX DESIGN WORK LIKE A WINDOW



### FREE HANGING DESIGN



- Tipper bottom should be able to flex in Y-direction
- Increased flexibility at the bottom will help to absorb impacts energy.



## 8. Important Design Aspects to consider

### Material Grade Selection

Hot rolled Plate	Hot rolled sheet
Hardox® 400	Hardox 400
Hardox® 450	Hardox 450
Hardox® 500Tuf	Hardox 500Tuf

- Hardox® Hi Temp – for Hot Steel Slag Transportation.
- Hardox® Hi Ace - Municipal waste Transportation
- Hardox® 500 can be used only for body liners

### Mechanical Properties

Grade	Thickness (mm)	Hardness <sup>1)</sup> (HBW)	Tensile strength R <sub>m</sub> (MPa), guaranteed	Typical yield strength (MPa), not guaranteed
Hardox® 450 CR sheet	0.8 - 2.10	425 - 475 <sup>2)</sup>	1370 - 1600	1250
Hardox® 450 sheet	2.0 - 8.0	425 - 475	-	1250
Hardox® 450 plate	3.2 - 80.0	425 - 475	-	1250
Hardox® 450 plate	80.1 - 103.0	410 - 475	-	1250
Hardox® 450 plate	103.1 - 130.0	390 - 475	-	1250

### Impact Properties

Grade	Longitudinal test, typical impact energy, Charpy V 10x10 mm test specimen.	Transverse test, guaranteed impact energy, Charpy V 10x10 mm test specimen.
Hardox® 450 sheet & plate	50 J/ -40 °C	-

### Product Programme and Data Sheets :

<https://www.ssab.com/products/brands/hardox/hardox-product-overview>

# 8. Important Design Aspects to consider

What is the load size ?  
 Local Drop height of the load ?  
 Operation Cycle ?  
 Environment Conditions ?

## Sheet Thickness Selection

### Rule of Thumb

- ✓ The rule of thumb gives the first idea about the potential to calculate the thickness of a part with same static strength.
- ✓ Example: Upgrading original Tipper Floor Sheet in 6mm S355 to Hardox 450




$$t_{HSS} = t \sqrt{\frac{R_E}{R_E^{HSS}}}$$

$$t_{HS} = 6 \cdot \sqrt{\frac{355}{1250}}$$

$$t_{HSS} = 3.2 \text{ mm}$$

(Hardox 450)

Typical upgrading of parts means weight reduction = ~ 25-30%.

Payload Particle Size	Duty Range	Parts	Hardox® 450
 Golf Ball	Light Duty	Sides Sheet Floor Bottom	3.2 mm 4 to 5 mm
 Foot Ball	Medium Duty	Sides Sheet Floor Bottom	4 to 6 mm 6 to 8 mm
 Basket Ball	Heavy Duty	Sides Sheet Floor Bottom	> 8 mm > 10 mm

\* - Source from Rule of thumb calculations

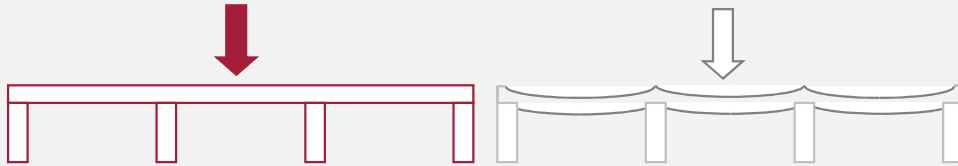
# 8. Important Design Aspects to consider

## Dent Resistant – Strong Structures

Stronger steel gives stronger structures.

HARDOX

Regular steel



MORE STIFFENERS



Regular steel needs stiffeners for support



HARDOX needs less stiffeners



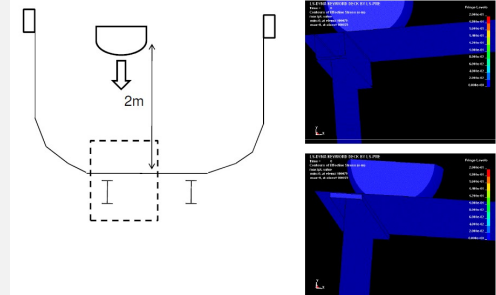
The strength in HARDOX withstand the force.



300 kg - 2,85 m - 600 x 600mm

Drop Hammer Test

FE Analyze 200 & 1500 kg



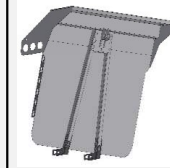
Finite Element Analysis

## 8. Important Design Aspects to consider

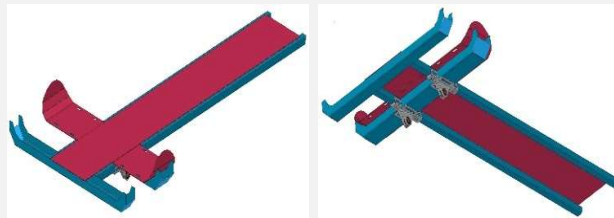
- Proper **NESTING** needs to be taken care to avoid costlier steel scraps.
- Design products using **STRIP MATERIALS** ( $\approx$ / $<$  1500 mm width). Also use cut to length plate & customized thickness.
- Plan the sub assemblies in **SKD FORM** so that it can be assembled any where.
- **MODULAR PRODUCT** solutions so that you can change the thickness and grade in line with application requirement.



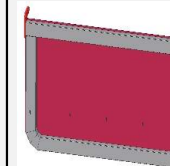
**Body Sides Assembly (LH & RH side)**  
– 3 mm thk Hardox 450 Strip - 1500 mm width



**Front Wall & Canopy**  
– 3 mm thk Hardox 450 Strip  
- 1500 mm width



**Bottom floor**  
– 4 mm thk Hardox 450 Strip  
- 1500 mm width



**Tailgate**  
– 3 mm thk Hardox 450 Strip  
- 1500 mm width

## 8. Important Design Aspects to consider

### SSAB - Bending Radii Recommendations

		THICKNESS (t) (mm)	TRANSVERSE TO ROLLING DIRECTION MINIMUM R/t	ALONG ROLLING DIRECTION MINIMUM R/t	DIE OPENING WIDTH (W) MINIMUM W/t
HOT ROLLED PLATE	Strenx 1300	t < 8	3.5	4.0	14
		8 ≤ t < 15	4.0	4.5	14
	Hardox 400	t < 8	2.5	3.0	12
		8 ≤ t < 15	3.0	4.0	14
		15 ≤ t < 20	3.0	4.0	14
		20 ≤ t < 50	4.0	5.0	16
	Hardox 450	t < 8	3.0	3.5	12
		8 ≤ t < 15	3.5	4.5	14
		15 ≤ t < 20	3.5	4.5	14
		t ≥ 20	4.5	5.0	16
Hardox 500	t < 8	3.5	4.5	14	
	8 ≤ t < 15	4.0	4.5	14	
	15 ≤ t < 20	4.5	5.0	16	
	t ≥ 20	5.5	6.0	18	
HOT ROLLED STRIP	Hardox 400	2 ≤ t < 4	3.0	4.0	12
		4 ≤ t ≤ 8	3.0	3.5	12
	Hardox 450	2.5 ≤ t < 4	3.0	4.0	12
		4 ≤ t ≤ 8	3.0	3.5	12
	Hardox 500	3 ≤ t ≤ 6.5	3.5	4.0	14

Due to

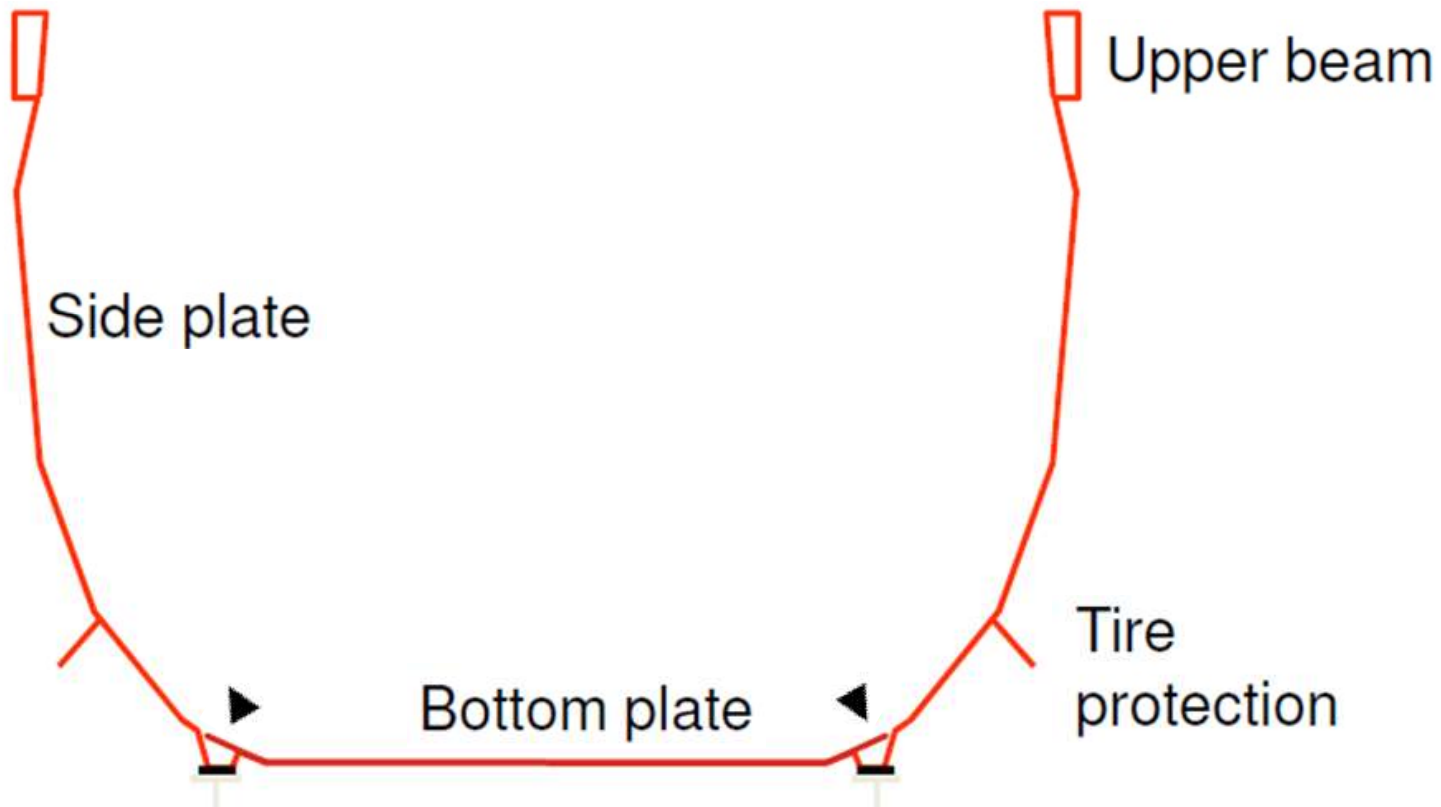
- High Tensile Strength
- High Hardness Material

We need more die punch radius & die opening width to bend the material without any failures

## 9. Design Ideas

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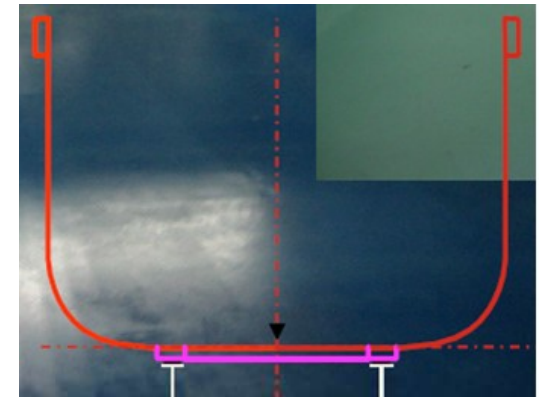
### i. The basic elements



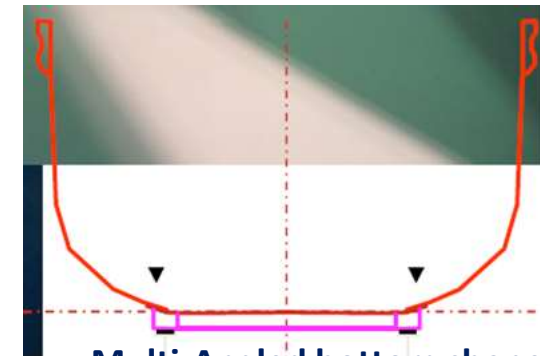
## 9. Design Ideas

### ii. Rounded Section (or) Multi Angled construction

- this shape helps the whole body to act more like a beam by itself.
- this shape will make it possible to remove the underlying heavy floor structure.
- this shape helps to build up membrane stresses along the plate without so much of deflection, therefore the stress level are lowered at welded joints.



**Rounded bottom shape**



**Multi-Angled bottom shape**

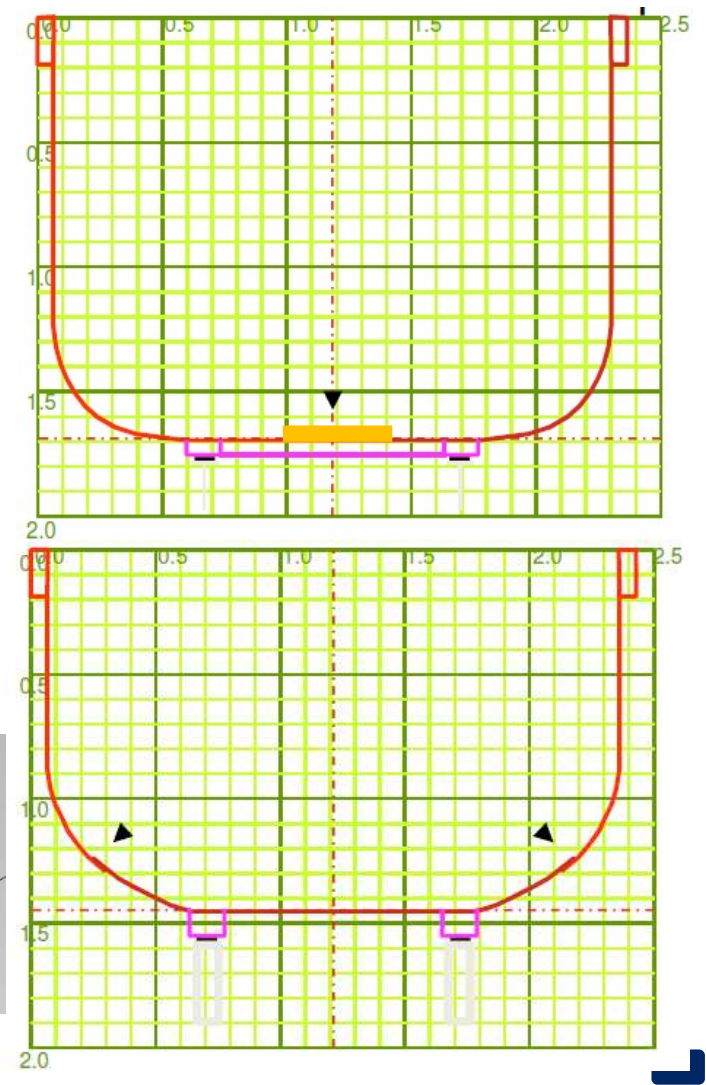
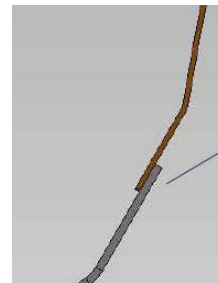
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## 9. Design Ideas

### iii. Two or Three Sheets construction

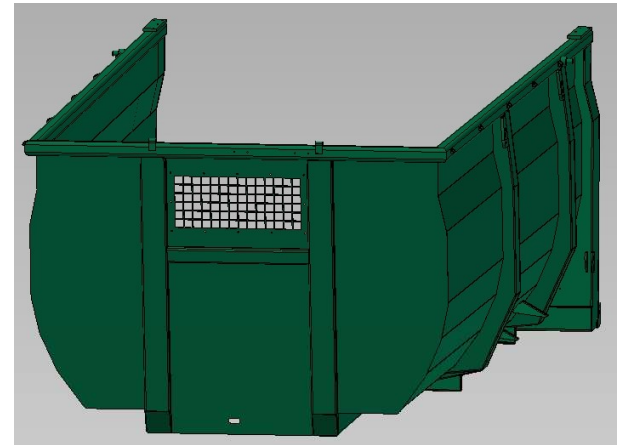
- ✓ Two sheets with single joint in the middle.
- ✓ Three plates with two joints in the sides.
- ✓ Place the weld some distance up along the side to avoid the higher stresses at the bottom.
- ✓ It is suggested to make an lap weld joint, which should be in a flat section, not too close to any bending line.



## 9. Design Ideas

### iv. Front Head Board

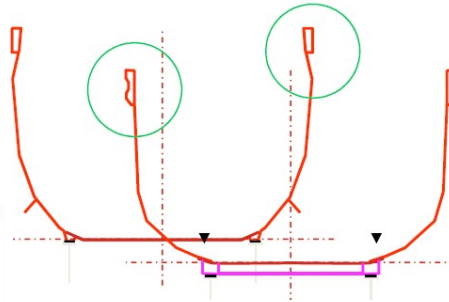
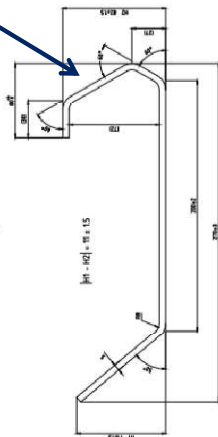
- ✓ It is common to use a thinner plate in the sides compared to bottom since there will be less loads & impacts at sides.
- ✓ However, for the front plate it is recommended to use the same thickness as for the bottom.
- ✓ Main reason is to keep stress down at the weld between the front & bottom, which will be at a sharp corner.
- ✓ Also, when the tipping cylinder is placed at the front, the front plate will also be distributing some forces.



## 9. Design Ideas

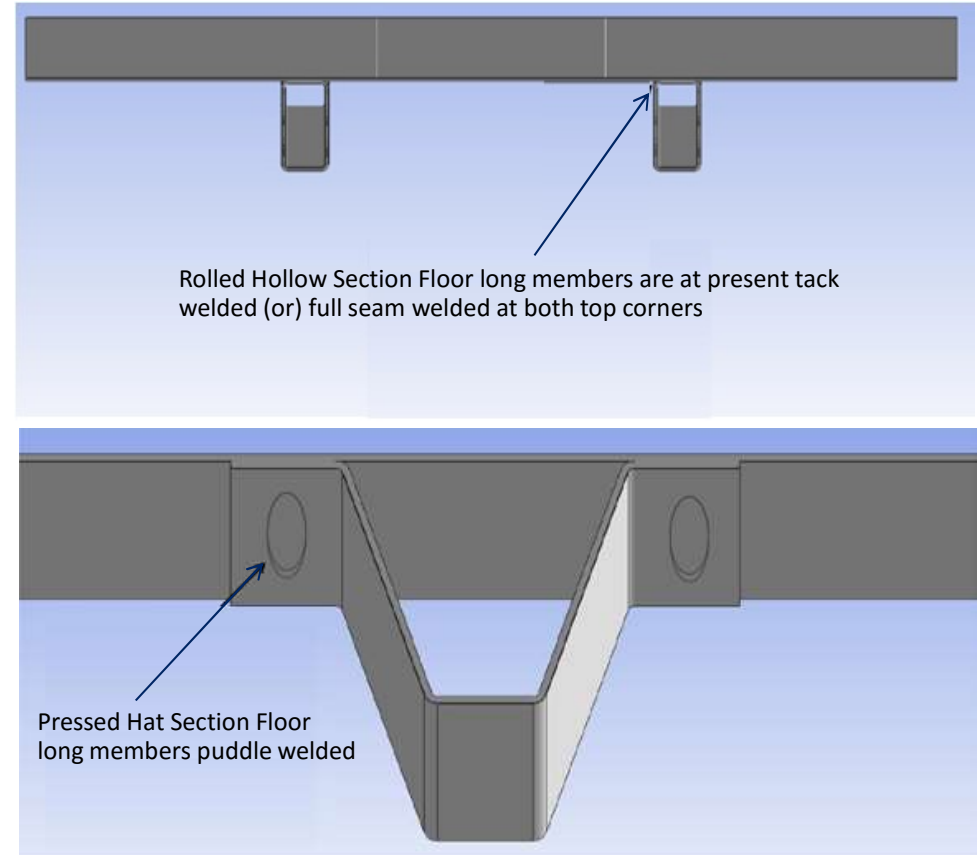
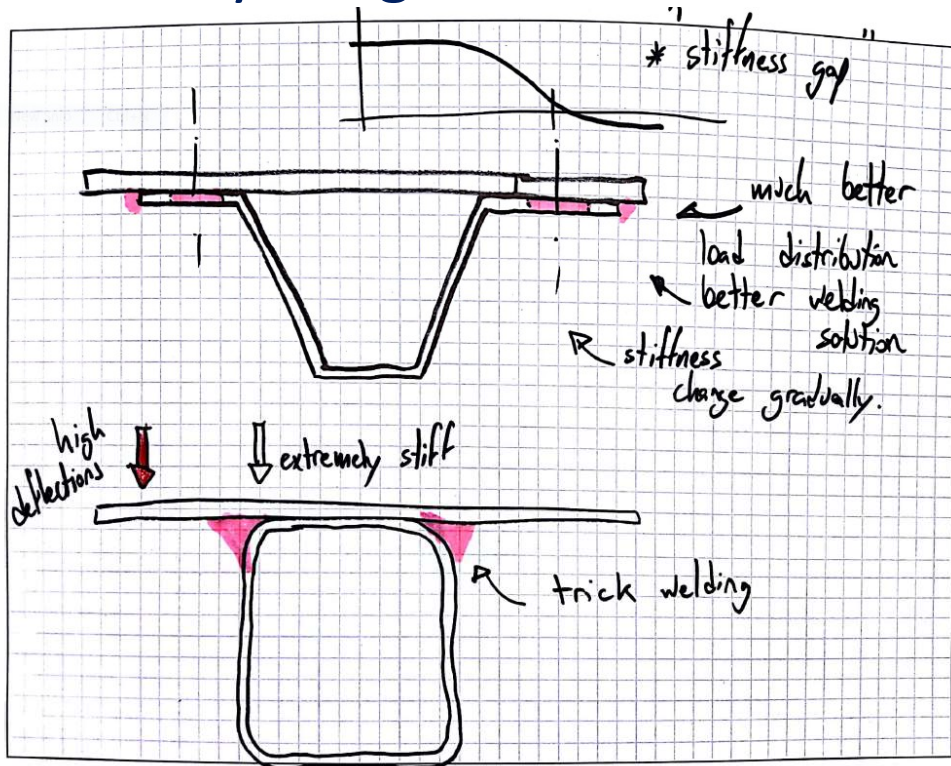
### v. Top Rails

- ✓ When the other vertical beams at the sides are removed, it may be required to make the Toprail stronger.
- ✓ Also, in a free hanging design, the body is more hanging from the top beam rather than standing on a frame.
- ✓ A sloping top, leaning inside lets the stone fall of easier. It deflects impact from the payload to the Top rail top



## 9. Design Ideas

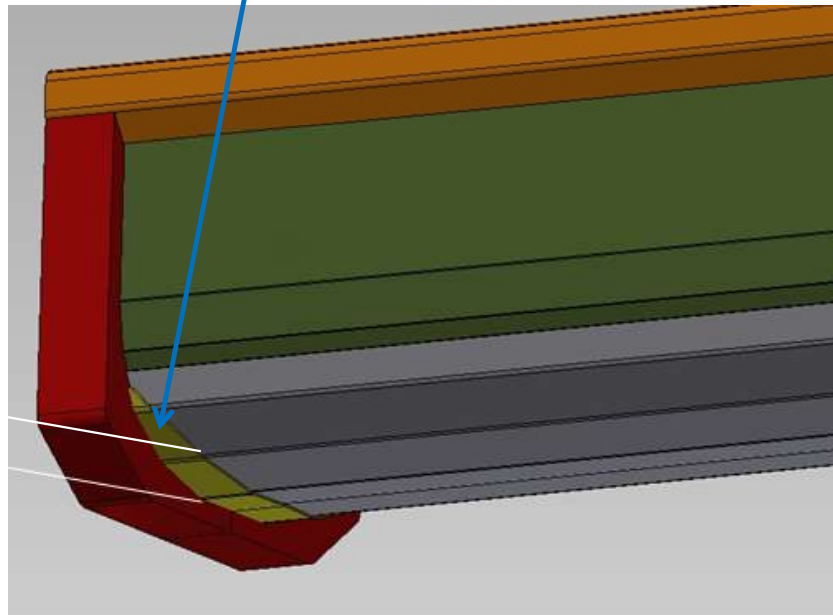
### vi. Body Long Members



## 9. Design Ideas

### vii. Rear Beam

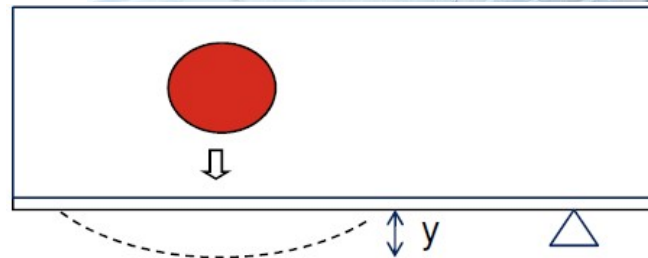
- ✓ When the other bottom beams are removed, there will be a rather **sharp stiffness transition** at the forward corner of the Rear Beam. This can lead to high stresses and accelerated wear at this point.
- ✓ It is therefore recommended to add a reinforcing **“Saddle Plate”** over the beam that will help to **even out the stiffness transition**.



## 9. Design Ideas

### viii. The Base Floor Support

- ✓ Rubber Support Continuous (or) Intermittent Cushions
- ✓ Wooden Support
- ✓ No Support



- Tipper bottom should be able to flex in Y-direction
- Increased flexibility at the bottom will help to absorb impacts energy.



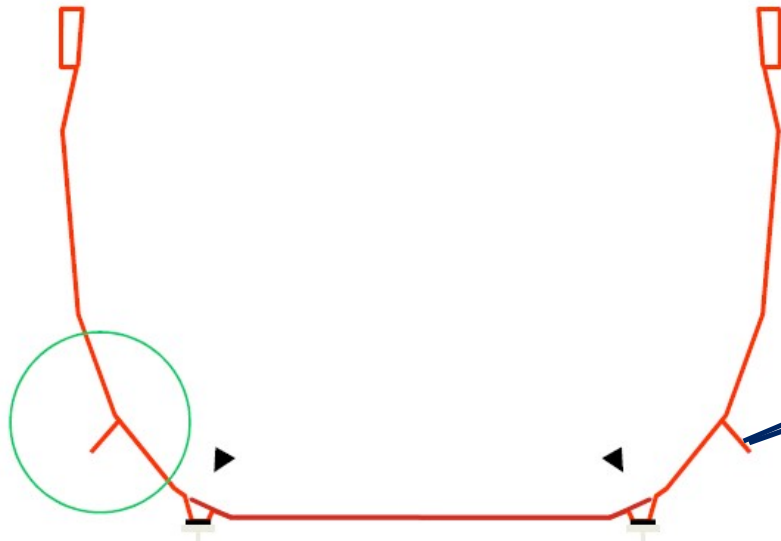
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## 9. Design Ideas

### ix. Accessories attachments

- ✓ Attached elements, as the tire protection & access ladders on the sides.
- ✓ Should not be directly welded to the body, but preferably bolted or welded to the consoles on the sides.



# 10. Example of an upgraded Hardox® Tipper



Modular Design – Suitable for Export Markets supply as SKD Kits.



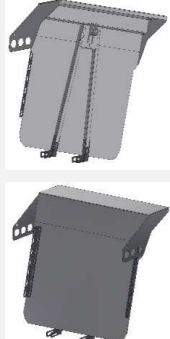
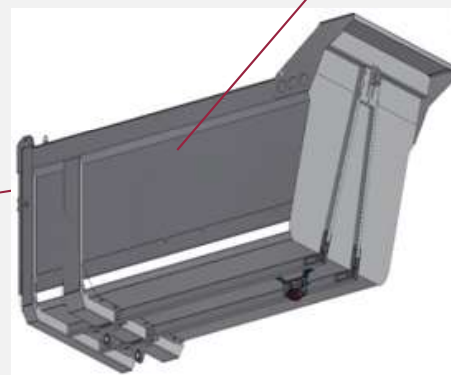
**Body Sides Assembly (LH & RH side)**

- Hardox Top Rail, higher resistance to impact
- **Floor (4 mm) to Side Wall (3 mm)** transition with high position of the Weld to reduce stress concentration



**Tailgate**

- Increased size of the frame in order to increase stiffness
- **Flat Wall in 3 mm thickness**



**Front Wall & Canopy**

- Inner reinforcements in the corners to increase stiffness
- Diagonal hollow sections for optimized transmission of forces from the bottom and into the cylinder attachment
- Plug welds to increase fatigue life.
- **Head Board in 4 mm thickness**



**Bottom floor**

- Single plate (no transversal welds) **in 4 mm thickness**
- **SHS Strenx 900 90 x 90 x 4 mm**

**Saddle plate (4 mm)** to minimize wear  
Cross reinforcement





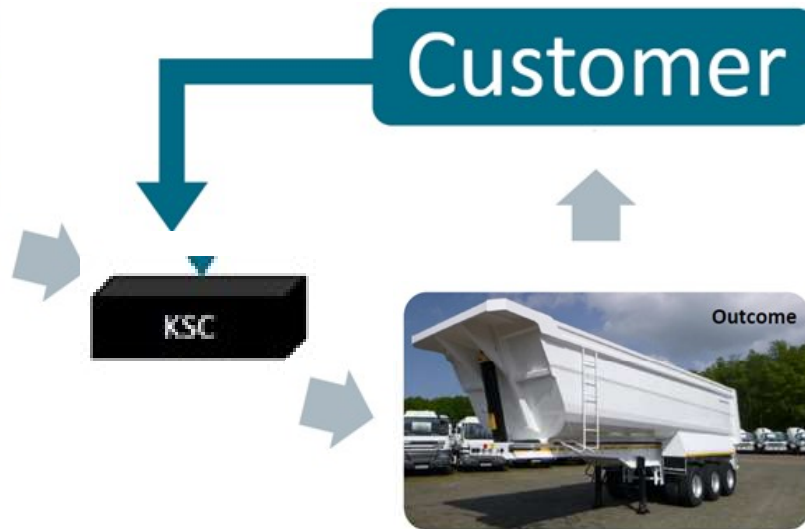
# 11. Hardox® in Action



Completed Prototypes Successfully running in the fields. Further many more prototypes work are in Progress



## 12. Let's upgrade! SHARE YOUR DESIGN CHALLENGES TO US !



### For more details about

- Right material Selection
- Right thickness selection
- Improving Wear resistance
- Improving Fatigue strength
- Welding & bending recommendations

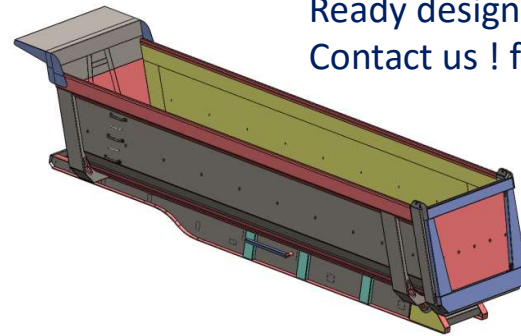
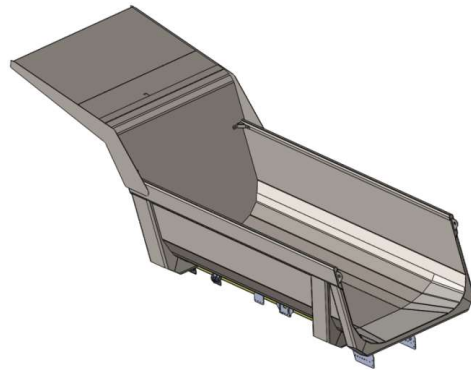
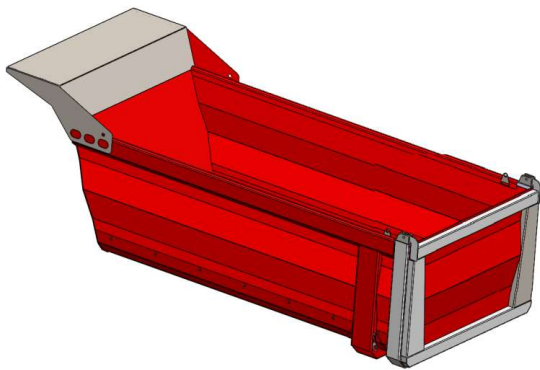
In particular to your applications please do contact us !

### SSAB Vision

A stronger, lighter and more sustainable world.  
Together with our customers, we will go further than anyone else in realizing the full potential of lighter, stronger and more durable steel products.

**SSAB**

## 12. Let's upgrade!



Ready design available with us.  
Contact us ! for building prototypes.

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## 13. Questions and discussions?

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*A stronger,  
lighter and more  
sustainable world*

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