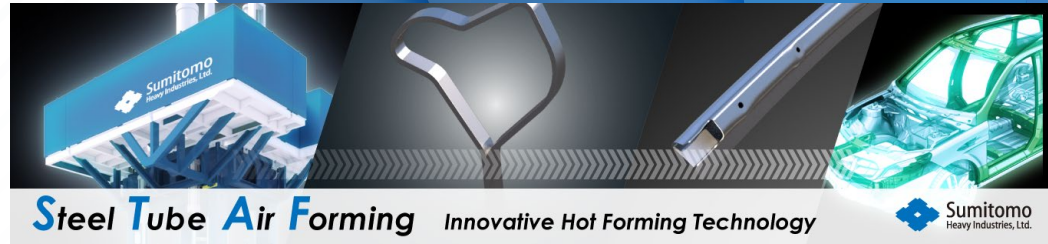


# GREAT DESIGNS IN STEEL

TWENTY YEARS



## Maximizing Light-weighting in Steel Automotive Bodies and Frames with Steel Tube Air Forming (STAF) Process

Ryuichi Funada, Sales Engineer  
Sumitomo Heavy Industries, USA Inc.

# Contents



- 1 . Introduction of STAF
- 2 . Positioning of STAF
- 3 . STAF's benefits
- 4 . Case study I & II
- 5 . Application for STAF

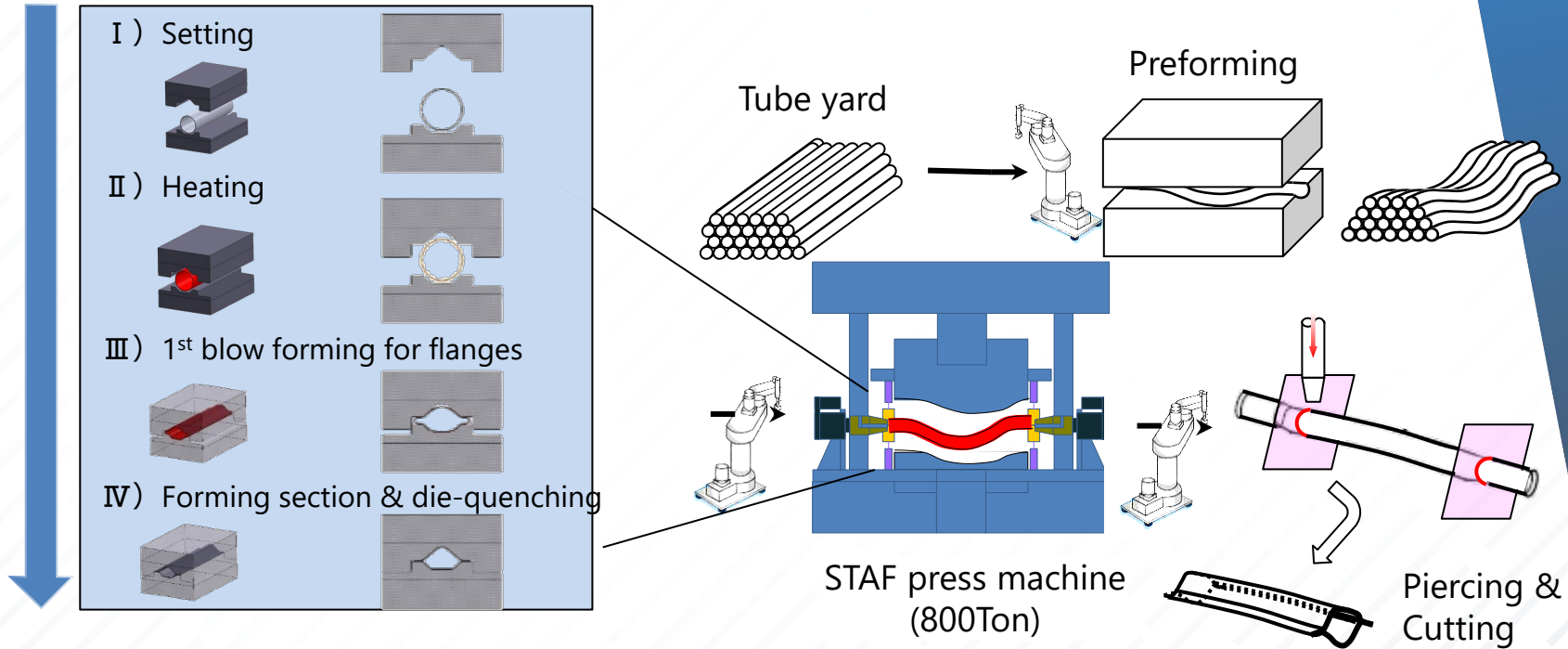
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# 1. Introduction of STAF

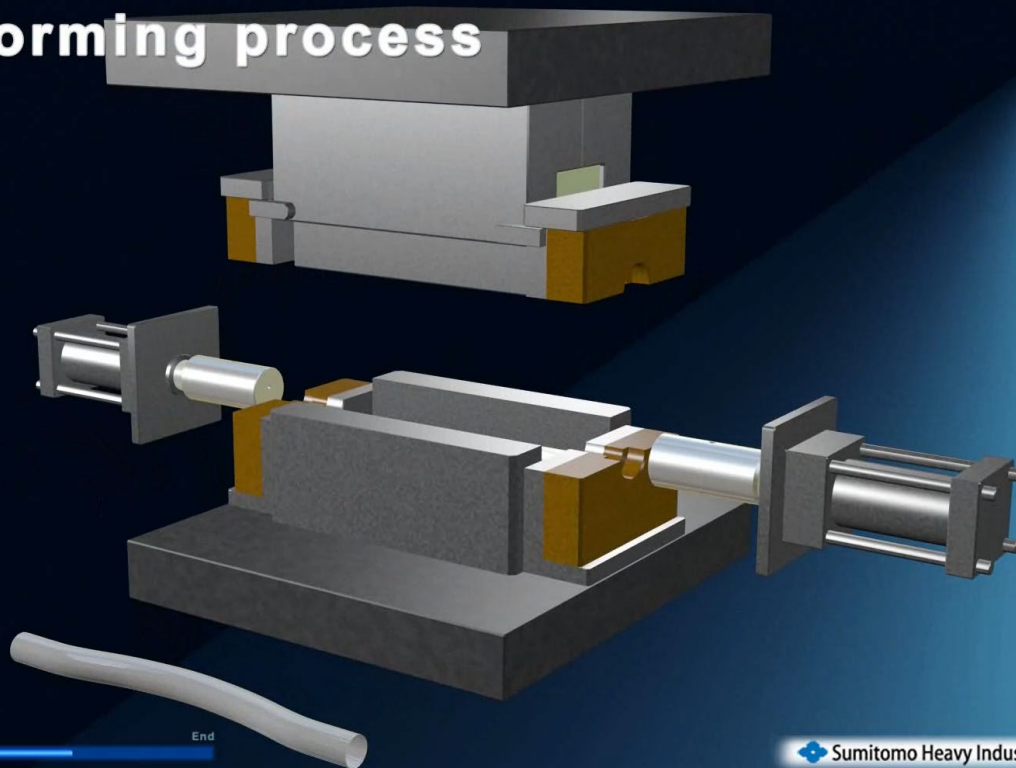
- Form high strength and high rigidity auto parts in one-pack
- Form flanges, drastically reduce the assembly processes



# 1. Introduction of STAF



## STAF forming process

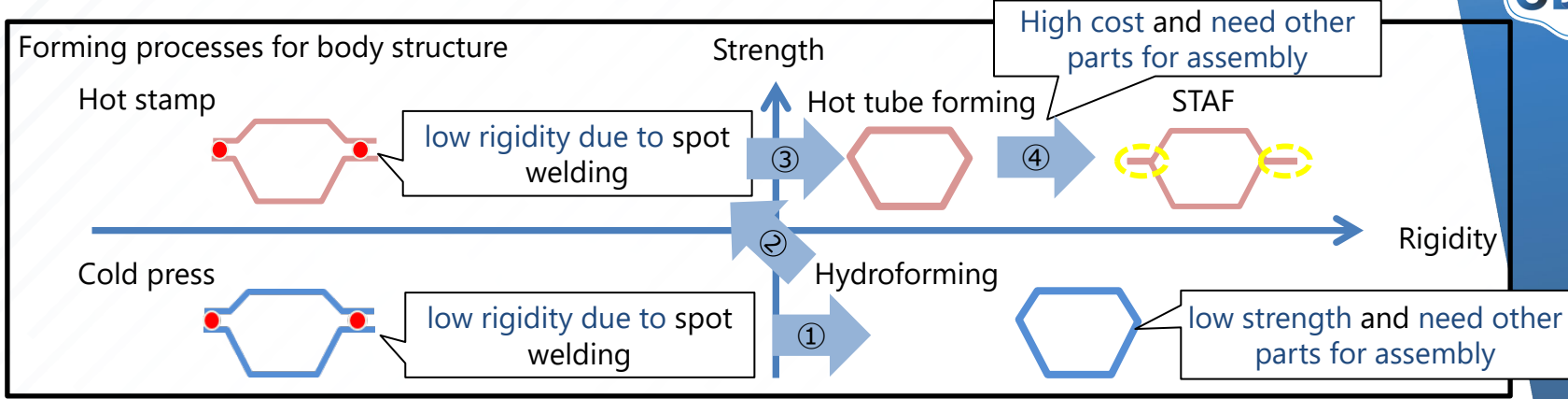


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# 2. Positioning of STAF



★ Invented    ■ Developed    ■ Promoted    ■ Adopted    ■ To be conventional

Flow of development		1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s	2020s	2030s
Forming processes	Cold press	Improved material yield, elongation and tension performance									
	Hydroforming		★								
	Hot stamping				★						
	Hot tube forming							★			
	STAF								★		

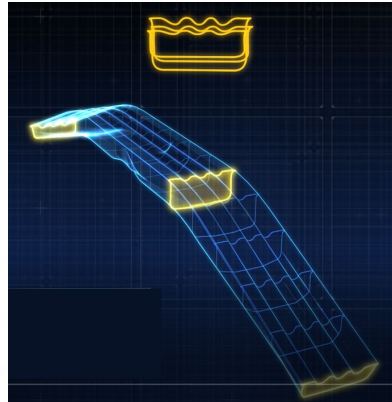
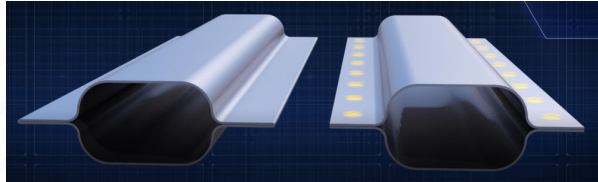
# 3. STAF's benefits

- Drastic weight reduction
- Performance can be controlled by flanges
- Simplification

STAF process can integrate surrounding components into STAF  
 Equipment for STAF is compact and well optimized

## + High versatility of spot welding connection

- ① Drastically weight reduction    ② Performance controlled by flanges    ③ Simplification

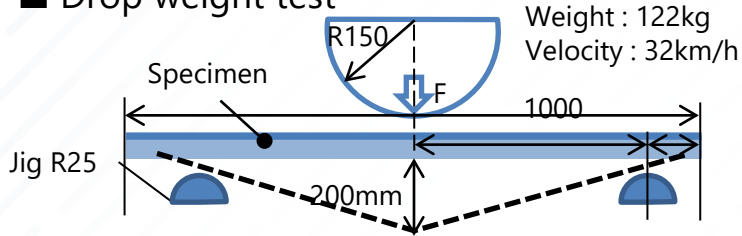




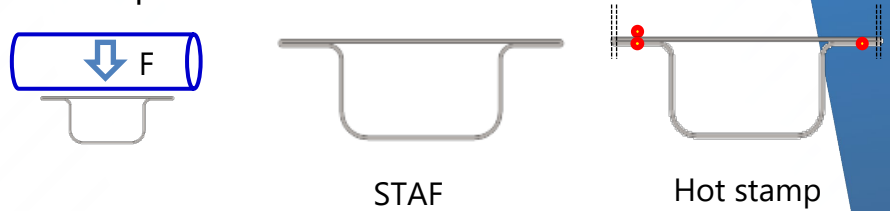
# 3. STAF's benefits

- Drastic weight reduction; Improved basic performance

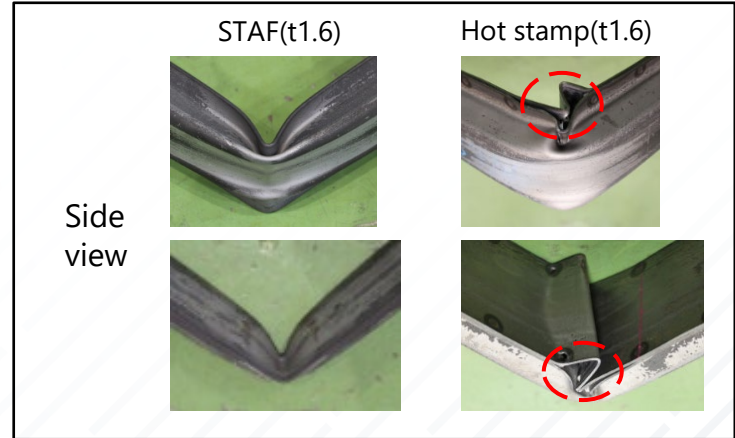
## Drop weight test



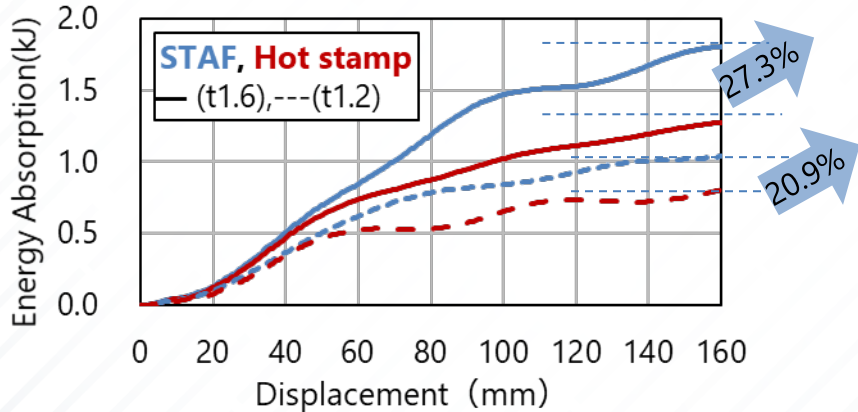
## Specimen's Cross section



## After collision



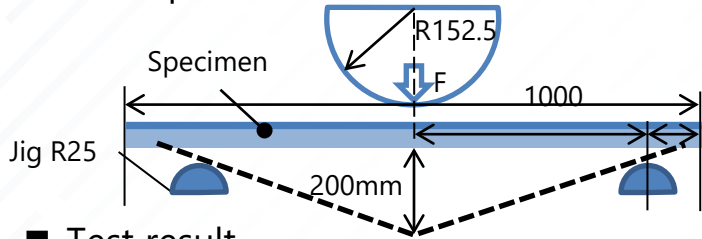
## Test result



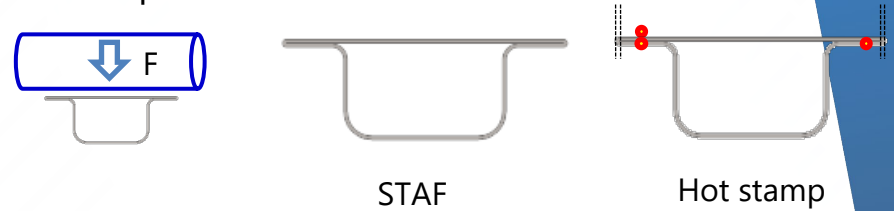
# 3. STAF's benefits

- Drastically weight reduction; Improved basic performance

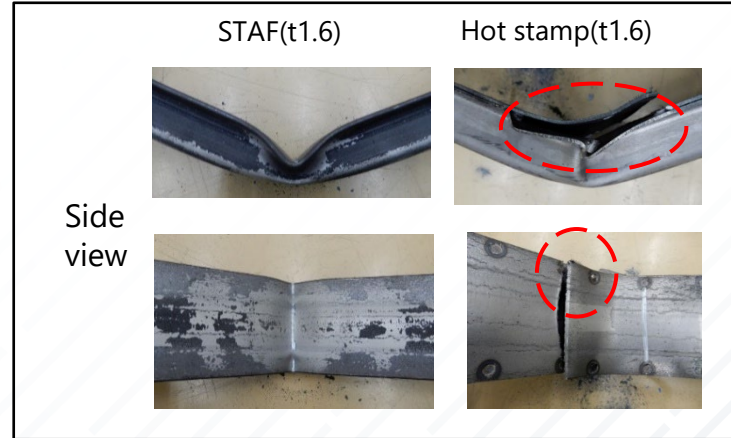
### ■ Three-point bend



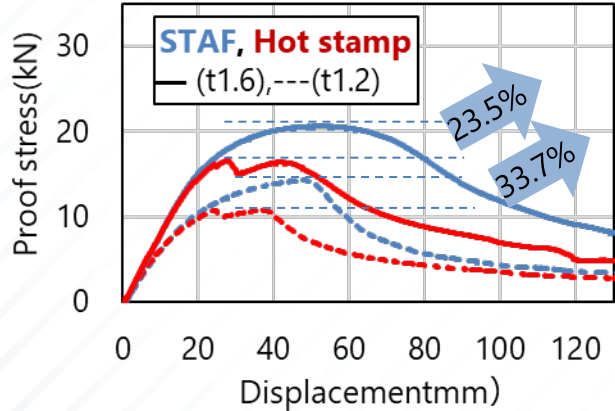
### ■ Specimen's Cross section



### ■ After collision



### ■ Test result

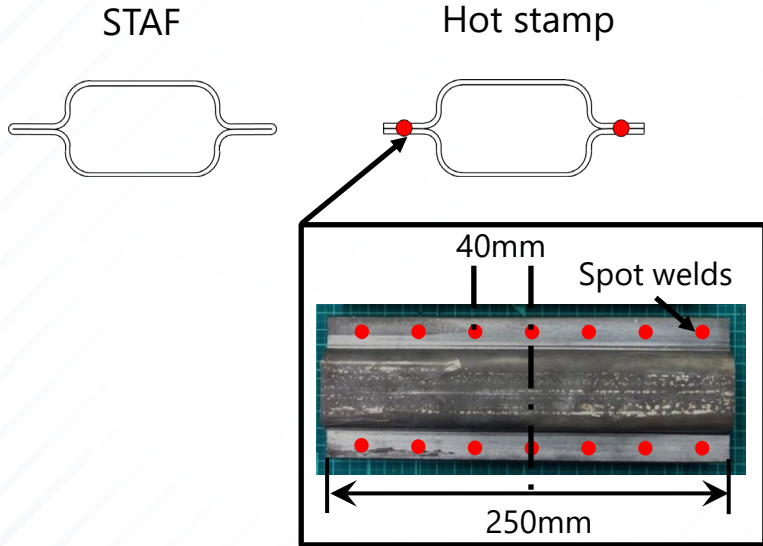


# 3. STAF's benefits

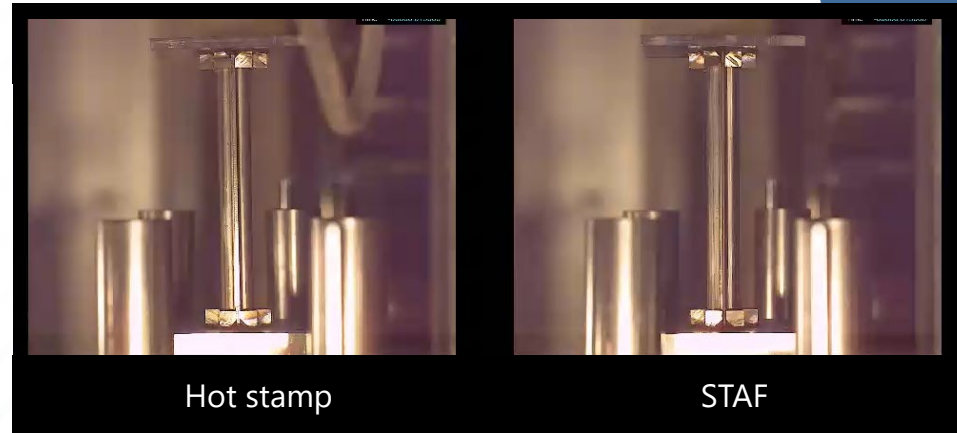
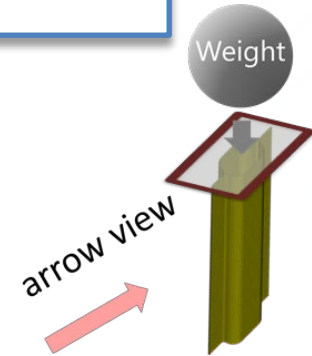
- Drastic weight reduction; Improved basic performance

■ Drop weight test-2

■ Specimen's Cross section

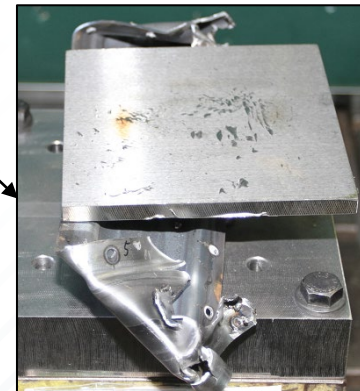
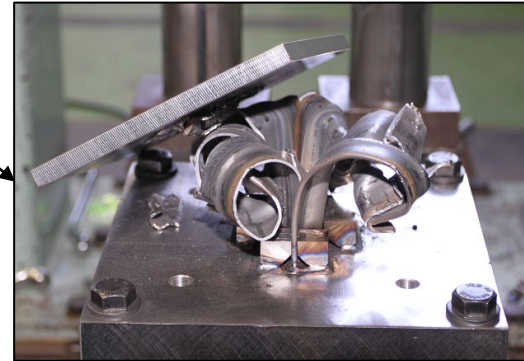
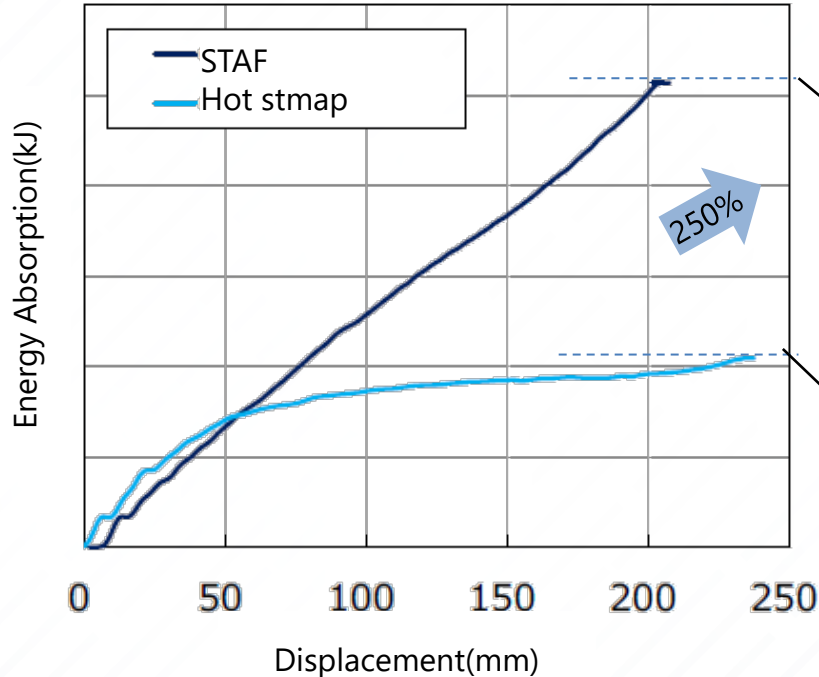


■ Test movie



### 3. STAF's benefits

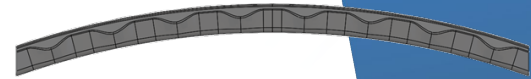
- Drastic weight reduction; Improved basic performance



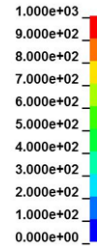
# 3. STAF's benefits

- Performance can be controlled by flanges

Models	No Flanged model		Minimum Flanged model	
Criteria Cross-section				
Stroke 20mm				
Stroke 40mm				
Stroke 60mm				

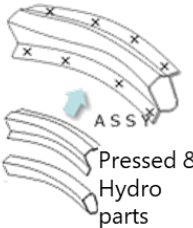
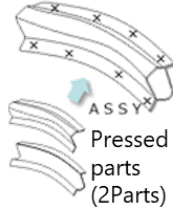

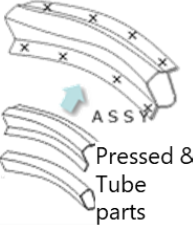


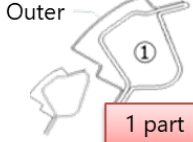
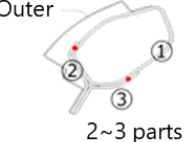


Beam profile



# 3. STAF's benefits

- Simplification (Integration and optimized equipment)

	Hydroforming	Hot stamping	STAF	Hot gas forming
Strength	~980MPa	<b>1,500MPa~</b>	<b>1,500MPa~</b>	<b>1,500MPa~</b>
Parts construction	 <p>Pressed &amp; Hydro parts</p>	 <p>Pressed parts (2Parts)</p>	 <p>STAF part (1 part)</p>	 <p>Pressed &amp; Tube parts</p>
Cross section image	2~3 Parts	2 Parts	1 Part	2~3 Parts
	 <p>Outer 2~3 parts</p>	 <p>Outer 2 parts</p>	 <p>Outer 1 part</p>	 <p>Outer 2~3 parts</p>
Process	5 processes	5 processes	<b>3 processes</b>	6 process
	<ul style="list-style-type: none"> <li>➢ Preforming</li> <li>➢ Hydroforming (3000Ton~)</li> <li>➢ Laser cutting</li> <li>➢ Press forming</li> <li>➢ Welding(ass'y)</li> </ul>	<ul style="list-style-type: none"> <li>➢ Blanking</li> <li>➢ Heating furnace</li> <li>➢ Hot stamping (2 Sheets &amp; 2 Dies)</li> <li>➢ Laser cutting</li> <li>➢ Welding(ass'y)</li> </ul>	<ul style="list-style-type: none"> <li>➢ Preforming</li> <li>➢ STAF form (800Ton~)</li> <li>➢ Laser cutting</li> </ul>	<ul style="list-style-type: none"> <li>➢ Preforming</li> <li>➢ Heating furnace</li> <li>➢ Gas forming</li> <li>➢ Laser cutting</li> <li>➢ Press forming</li> <li>➢ Welding(ass'y)</li> </ul>

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# **CASE STUDY I FOR BUMPER BEAM VERIFICATION OF STAF'S BENEFITS**

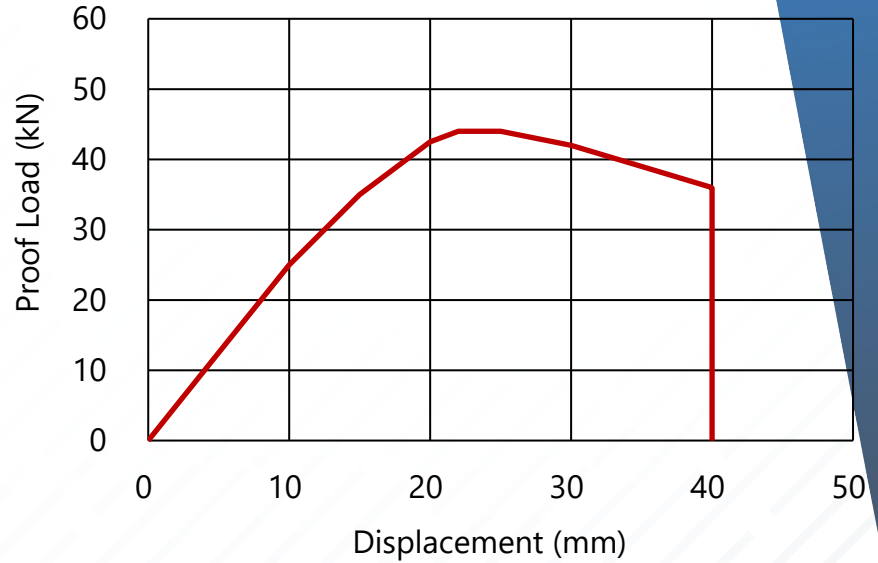
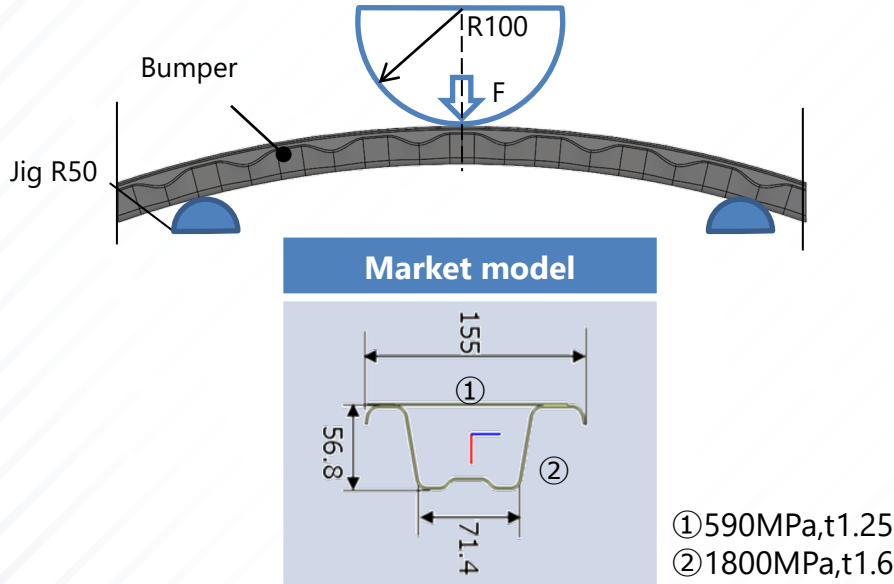




# 4. Case study

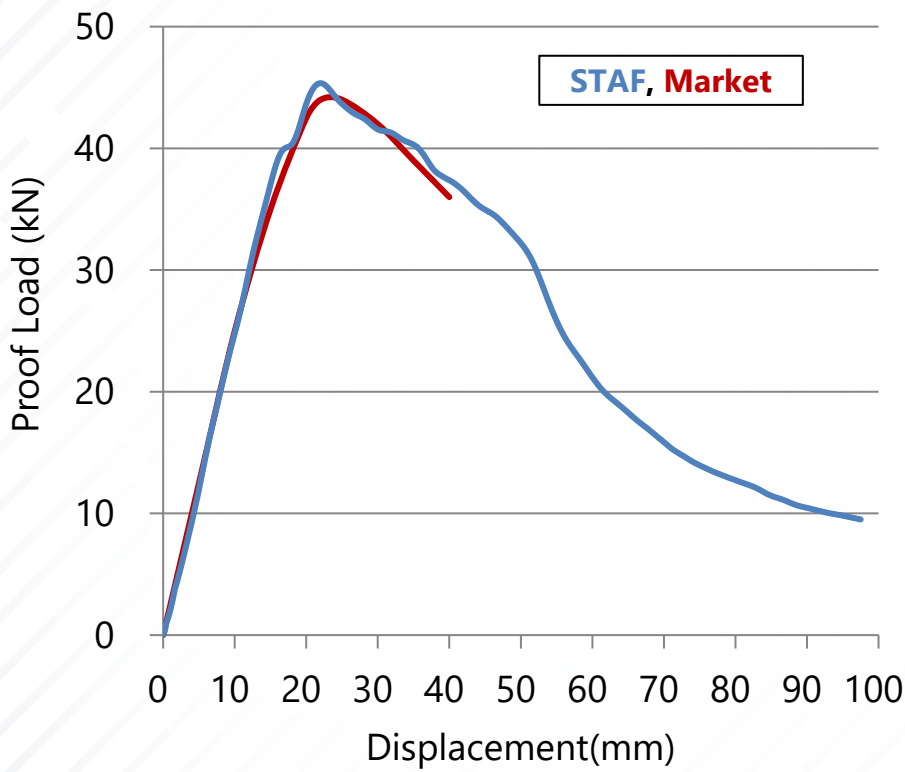
- We replaced a conventional bumper with STAF. STAF is designed under the same layout of conventional. We tested this evaluation with several strength evaluation, for this page introduce the basic performance.

## ■ Evaluation (three-point bend)



# 4. Case study

■ Test result (three-point bend)



Model	Market model	STAF model
Pipe diameter (mm)	—	φ114.3
Thickness (mm)	①590 MPa, t1.25 ②1800 MPa, t1.6	1500 MPa, t1.2
Cross section		
Weight (kg)	5.15	3.72 (⊖ -27.7%)

# 4. Case study



Cost Comparison	Market model	STAF																				
Bumper section																						
Manufacturing Cost (SHI's estimation)	<table border="1"> <caption>Manufacturing Cost Breakdown (Estimated %)</caption> <thead> <tr> <th>Component</th> <th>Material</th> <th>Press</th> <th>Weld</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>CLOSING PLATE</td> <td>10</td> <td>15</td> <td>10</td> <td>35</td> </tr> <tr> <td>BUMPER</td> <td>30</td> <td>20</td> <td>0</td> <td>50</td> </tr> <tr> <td>STAF-BEAM</td> <td>40</td> <td>35</td> <td>0</td> <td>75</td> </tr> </tbody> </table>		Component	Material	Press	Weld	Total	CLOSING PLATE	10	15	10	35	BUMPER	30	20	0	50	STAF-BEAM	40	35	0	75
Component	Material	Press	Weld	Total																		
CLOSING PLATE	10	15	10	35																		
BUMPER	30	20	0	50																		
STAF-BEAM	40	35	0	75																		
%	<div style="display: flex; justify-content: space-between;"> <span>1 0 0 %</span> <span>8 0 . 3 %</span> </div>																					

These cost numbers are calculated based on SHI's standard, not guaranteed.

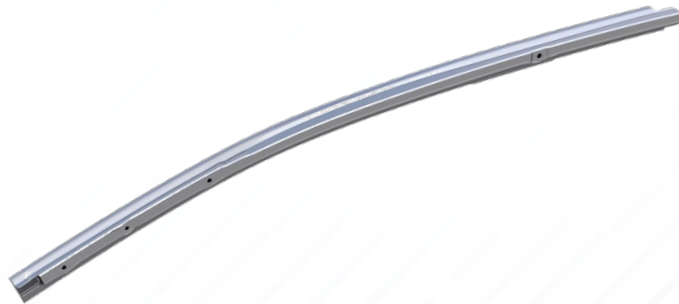
## 4. Case study

### ■ Summary

#### STAF applicability to Bumper beam

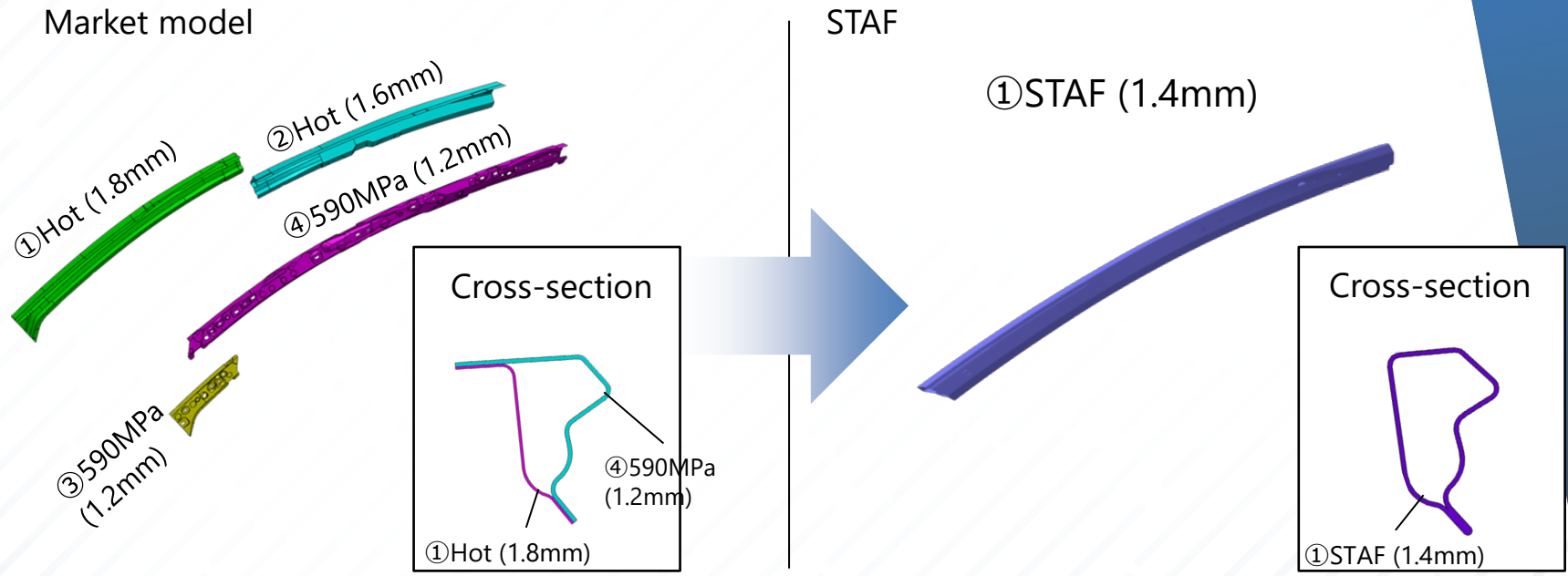
1. In this test condition (3point bending), it is possible to reduce **the weight by 27.7%**, compared with conventional bumper of hot stamped. (Apple to Apple same layout design comparison)
2. By reducing the number of parts, production efficiency and the number of dies, manufacturing cost will be reduced **by 19.65%**.
3. Structure that cannot be manufactured by other forming process

# **CASE STUDY II FOR A PILLAR VERIFICATION OF STAF'S BENEFITS**



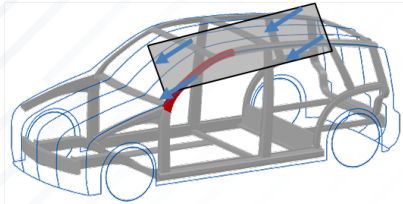
# 4. Case study

- We replaced a conventional A-pillar in the market with STAF process. The conventional model is composed of four reinforcements, each of which is spot welded together. With STAF, those parts can be integrated into a single part at once.

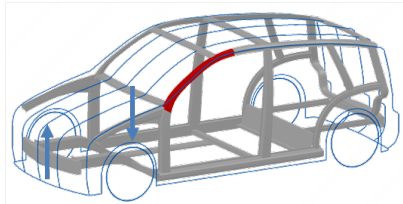


# 4. Case study

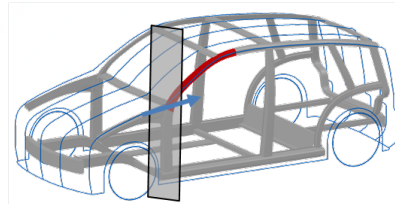
■ Evaluation We have studied various requirements of A pillar as below.  
In order to prove the basic performance of STAF, I will explain the performance with Full Frontal Crush.



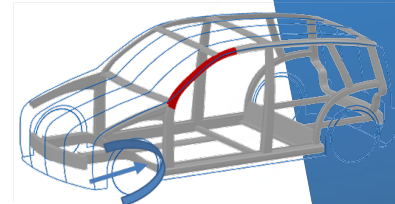
FMVSS216:Roof crush



Body torsion performance



Frontal crush



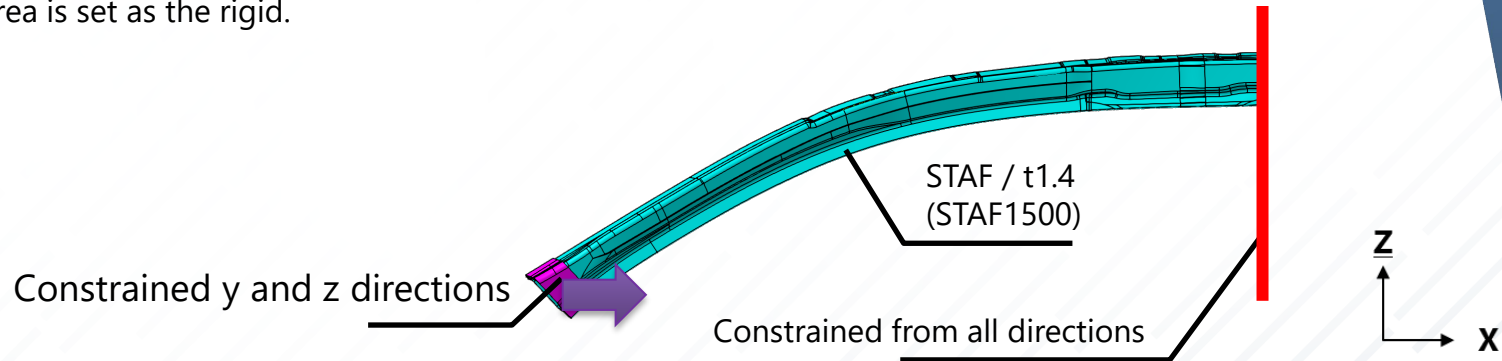
Small overlap frontal crush

## ■ Full-Frontal crush test(CAE)

Solver : LS-DYNA

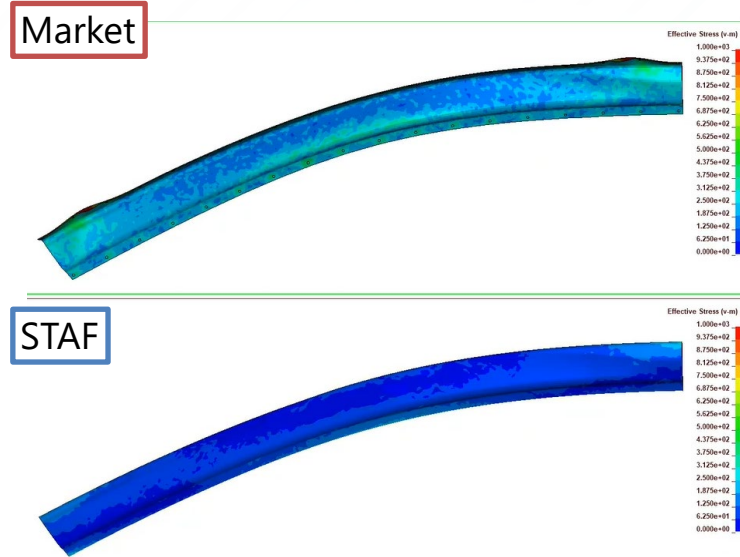
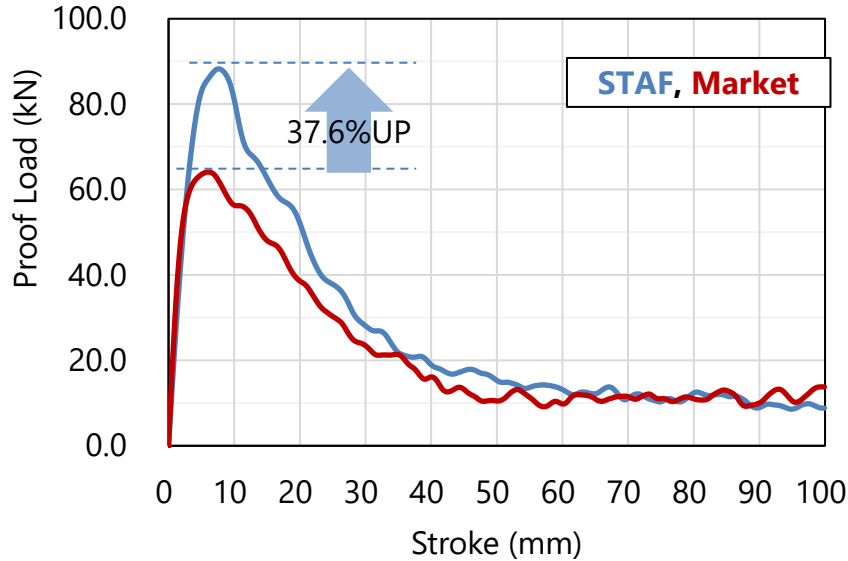
Methods : Forcibly the contact area is moved at 0.5 mm / sec to evaluate the load and energy absorption.

\*The contact area is set as the rigid.



# 4. Case study

## ■ Test Result



	STAF	Market model
Parts count	1 part ↓ Reduce 3 parts	4 parts
Weight	3.8kg ↓ 31% Weight reduction	5.5kg



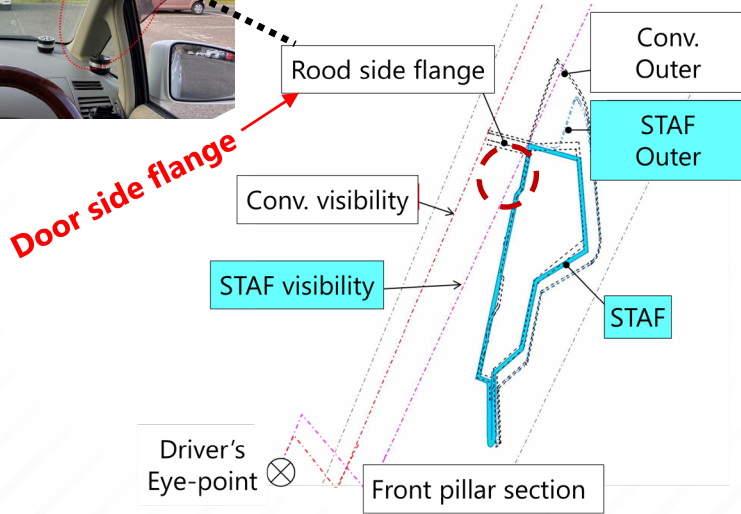
# 4. Case study

## ■ Additional features for A pillars

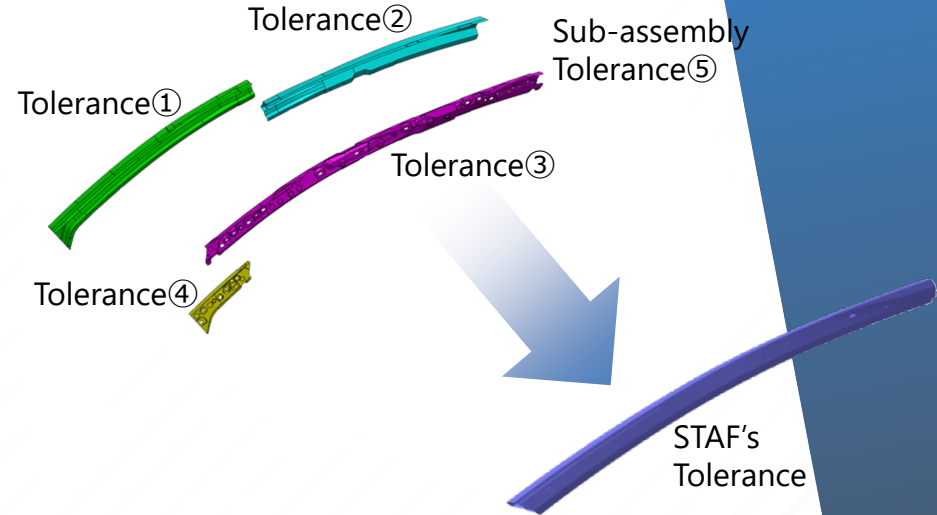
### ① Improvement of visibility



The pate used for a flange also can be replaced for enlarging the section size, so the weight can be further reduced.



### ② Improvement of assembly accuracy

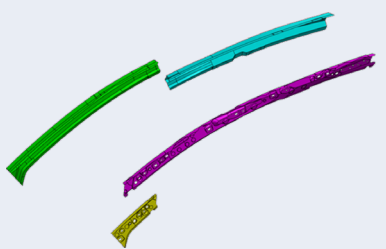



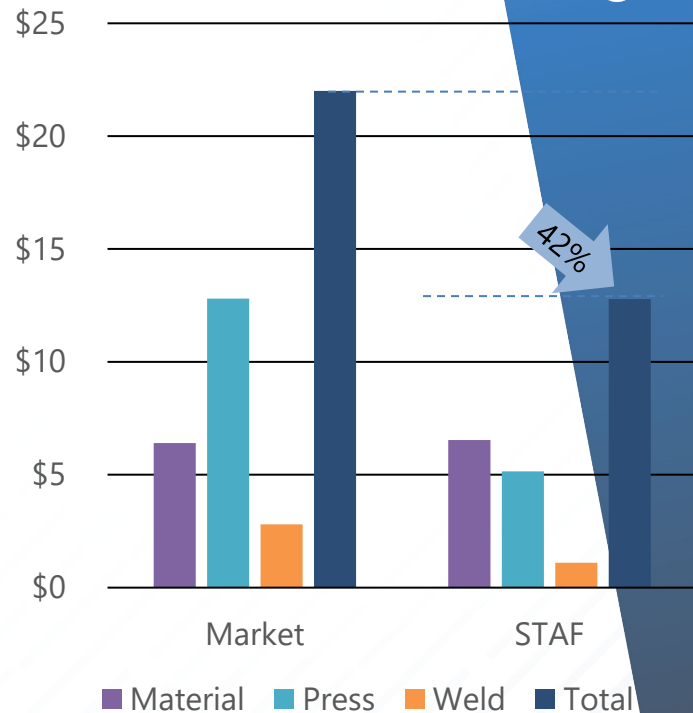
A-pillars processed by conventional forming processes requires some parts for sub-assembly. Assembly accuracy will be deteriorated for each part. Additionally if laser or mig welding are used, the total accuracy will be worse.

# 4. Case study

## ■ Cost comparison



Cost Comparison	Market model	STAF
		
Parts count	4	1
Die count	4	1
%	100%	58%



## 4. Case study

### ■ Summary

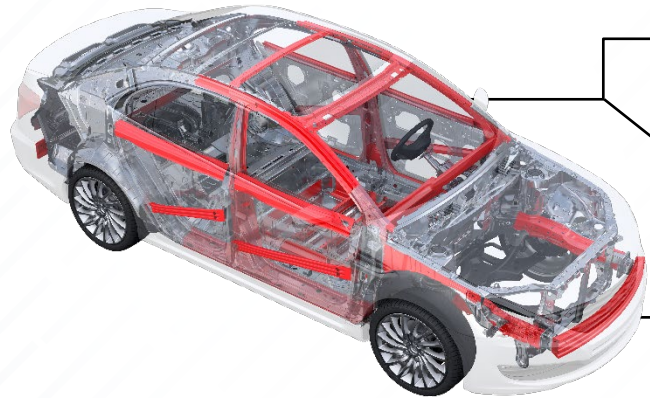
#### STAF applicability to A-pillar test

1. In this test condition (Front crush test), it is possible to reduce **the weight by 31%**, compared with conventional A pillar of hot stamped. (Apple to Apple same profile comparison)
2. By reducing the number of parts, production efficiency and the number of dies, manufacturing cost will be reduced **by 42%**.
3. Structure that cannot be manufactured by other forming process

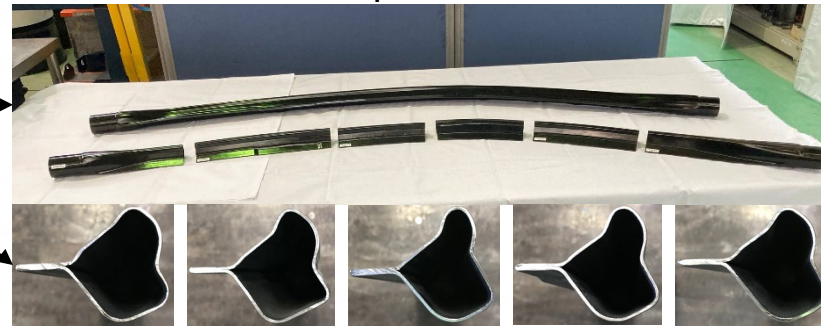
# 5. Application for STAF

The parts below are just examples of the prototype parts that we are studying with our customers (OEMs and Tier1 suppliers). We have verified that compared with conventional body frame parts, STAF's unique high-strength tubular flanged components can make joining easier, performance higher, manufacturing cost lower.

Red: Body frame parts to which STAF is applicable



Front pillar

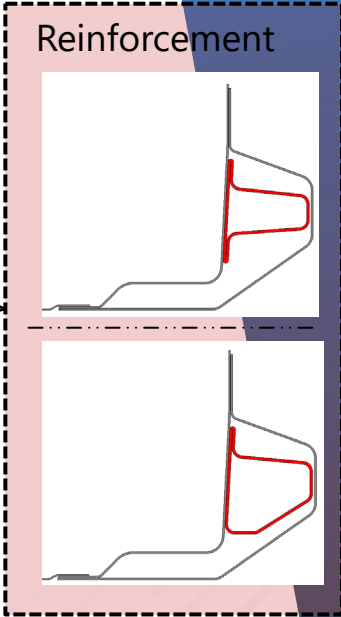
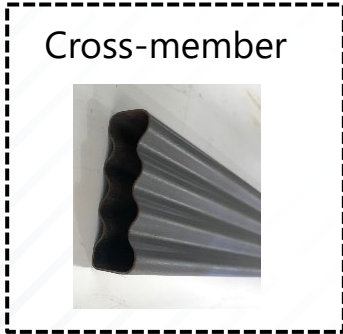
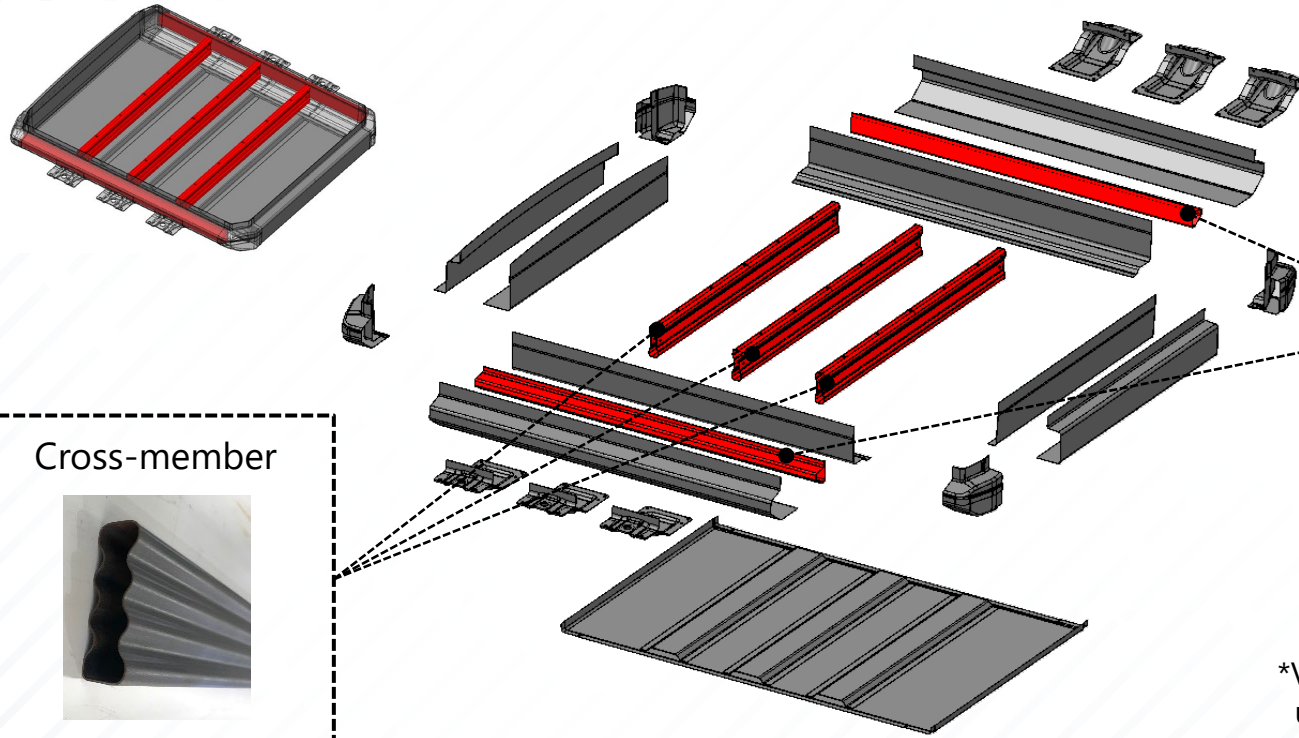


Bumper reinforcement



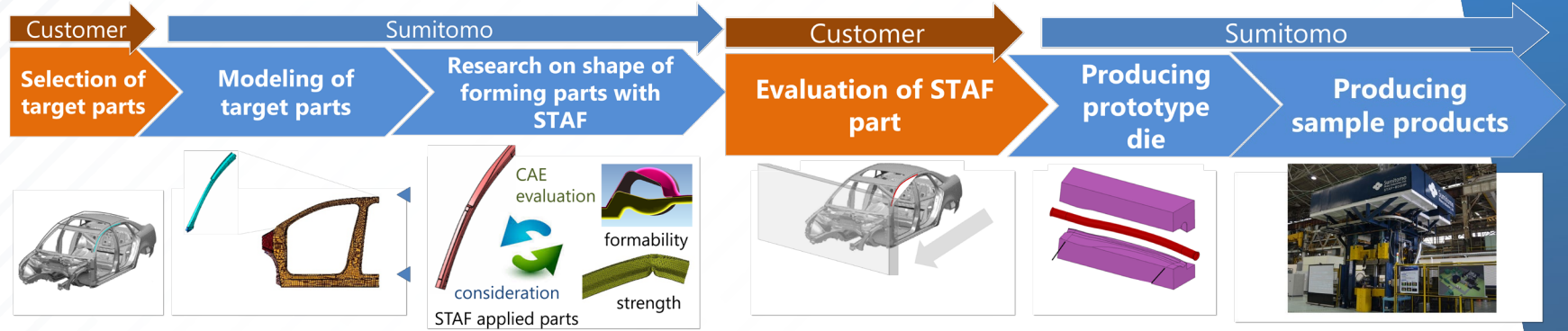
# 5. Application for STAF

## ■ New Application (Battery Frame Reinforcement)



\*Various section profiles are available upon performance/LO requirements.

# 5. Application for STAF



Through these activities, Sumitomo can provide the technical know-how in the feasibility and strength confirmation CAE that have already been verified, and the confirmation results such as the weldability, formability and corrosion protection of STAF product, etc., The adoption of STAF by OEMs and Tier1 suppliers can be strongly promoted.

# For more information



Thank you all for listening!

If you are interested in STAF and like to hear more details, please feel free to contact us at:



**Ryuichi Funada**

Sumitomo Heavy Industries (USA), Inc.

Technical Sales and Engineering Group

STAF Project

Advanced Technology of Plasticity - SBU

Office (Columbus Branch)

5100 Parkcenter Ave Dublin

OH 43017

USA

Email: [ryuichi.funada@shi-g.com](mailto:ryuichi.funada@shi-g.com)

Cell: +1 (614) 896 - 0282