

TRIP

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## Analysis and Assessment of Side Impact of an Auto-body with TRIP Steel

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**Abstract:** This paper introduces side impact of an auto-body with reinforced with TRIP steel for the purpose of safety enhancement and weight reduction. Cowper-Symonds model and Johnson-Cook model have been applied to the analysis in order to investigate the strain rate effect compared to the quasi-static model. The analysis has made TRIP steel supersede the conventional low carbon steel for center pillar and side sill of auto-body side structures. Side impact analysis has been carried out based on the condition in FMVSS 214. The numerical simulation has been performed with LS-DYNA3D in order to investigate the effect of TRIP steel on the dynamic response in side impact as well as the strain rate hardening effect. Analysis results show that auto-body structures reinforced with TRIP steel are desirable for weight.

1.

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30%

TRIP(Transformation Induced Plasticity) 가

가가 가

가

TRIP

(center pillar)

(side sill) 60TRIP

가

가

## 2.

NHTSA

가

FMVSS(Federal Motor Vehicle Safety Standard) 214

1)

FMVSS 214 15

mph

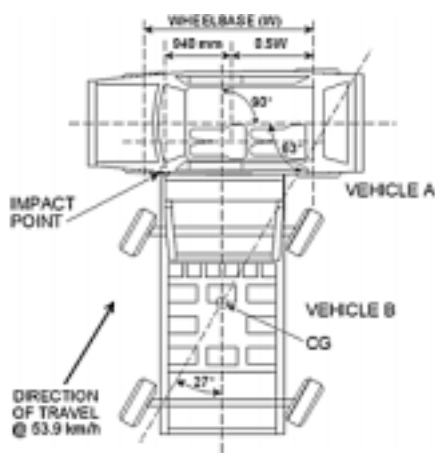
30 mph

27

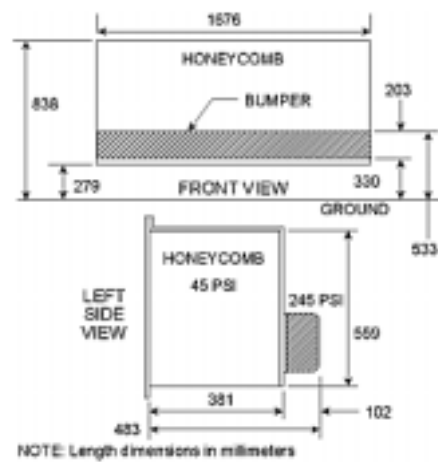
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33.5 mph(53.9 km/h)



(a)



(b)

Fig. 1 FMVSS 214 test: (a) test configuration; (b) moving deformable barrier.

Fig.1 FMVSS 214 가 1367kg  
 940mm A-  
 (moving deformable barrier) (honeycomb)  
 (bumper)  
 (dummy)  
 가 가 가  
 가 NCAP(New Car Assessment Program)  
 FMVSS 214 가 가 38.5 mph

### 3.

3.1

Fig. 2 78112 75828  
 , 285 10994 7324 3  
 614  
 LS-DYNA3D<sup>2)</sup>  
 FMVSS 214  
 70 msec HPC320 24  
 28 12  
 Cowper-Symonds<sup>3)</sup> 가  
 60TRIP Johnson-Cook  
 Cowper-Symonds (1)

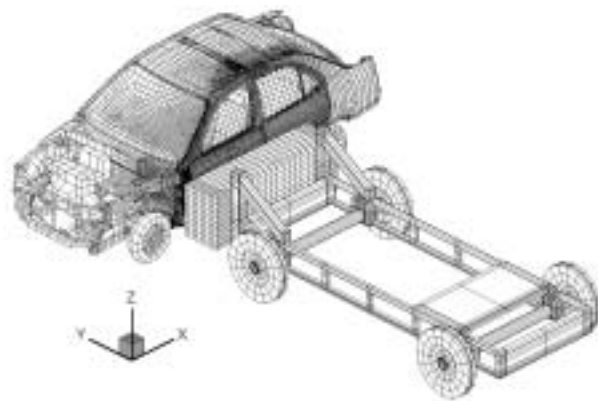


Fig. 2 Finite element model for side impact analysis.

$$\sigma(\varepsilon, \dot{\varepsilon}) = \sigma_0(\varepsilon) \left[ 1 + \left( \frac{\dot{\varepsilon}}{D} \right)^{\frac{1}{p}} \right] \quad (1)$$

$\sigma_0(\varepsilon)$  ,  $\dot{\varepsilon}$  ,  $D$  ,  $p$

60TRIP

Johnson-Cook

4)

Johnson-Cook

Johnson-Cook

$$\bar{\sigma} = [A + B\bar{\varepsilon}^n] [1 + C \ln \bar{\dot{\varepsilon}}] [1 - T^{*m}] \quad (2)$$

$$T^* = \frac{T - T_{room}}{T_{melt} - T_{room}} \quad (3)$$

60TRIP

Johnson-Cook

5-8)

3.2

Cowper-

Symonds

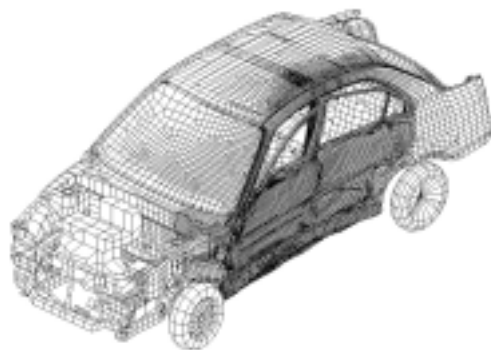
Fig. 3 70 msec

가 Cowper-Symonds

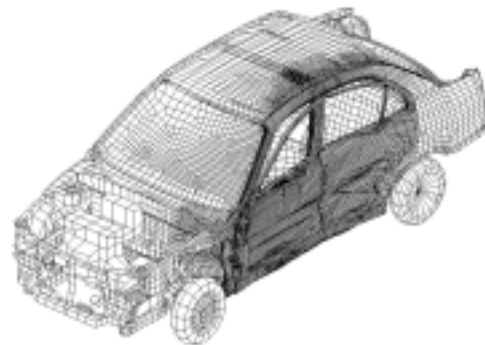
가 가

(door) 가

가 Cowper-Symonds



(a)



(b)

Fig. 3 Deformed shapes of an auto-body after 70 msec: (a) the quasi-static model; (b) Cowper-Symonds model.

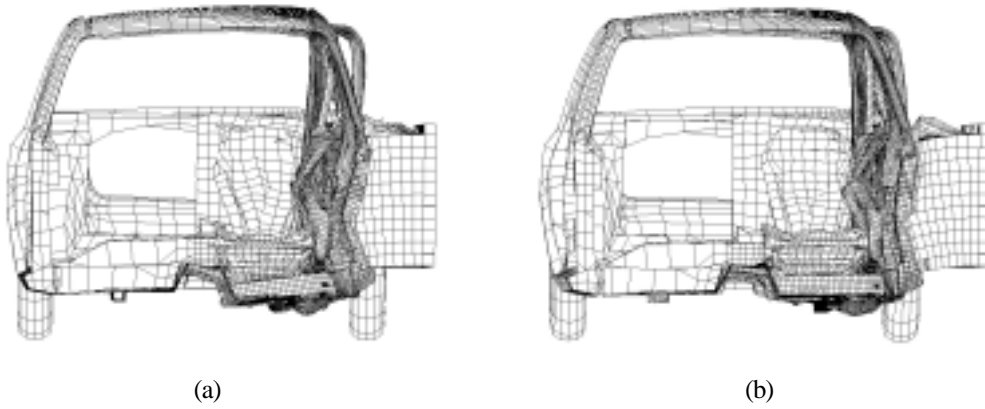


Fig. 4 Deformed shapes of a passenger compartment after 70msec: (a) the quasi-static model; (b) Cowper-Symonds model

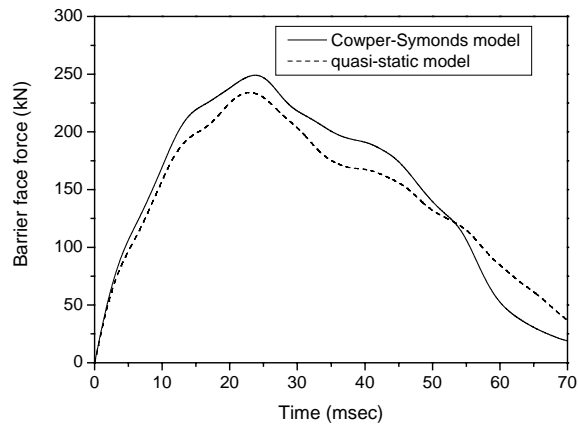


Fig. 5 Barrier face forces with respect to material constitutive model.

가 Cowper-Symonds

. Cowper-Symonds

가

. Fig. 4

FMVSS 214

가

가 . 70 msec

가

Cowper-Symonds

Fig. 5

가

23 msec

Cowper-Symonds

가

. Cowper-Symonds

가 . 55 msec  
 가 Cowper-Symonds  
 , 가

### 3.3 60TRIP

60TRIP , 가  
 60TRIP , 60TRIP  
 60TRIP ,  
 가 .

Fig. 6 60TRIP -  
 가 1/sec . TRIP  
 가 가 가 가 ,  
 60TRIP 1.2 가 가

Fig. 7 Fig. 8  
 60TRIP . 35 msec  
 가 40 msec  
 가 .  
 60TRIP . Fig. 7 Fig.

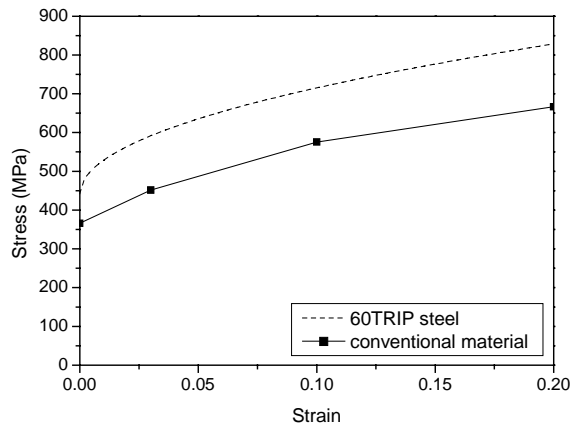
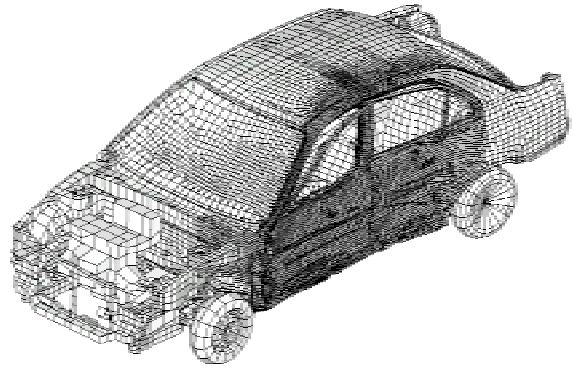


Fig. 6 Stress-strain curves of 60TRIP steel and the conventional material at strain rate 1/sec.

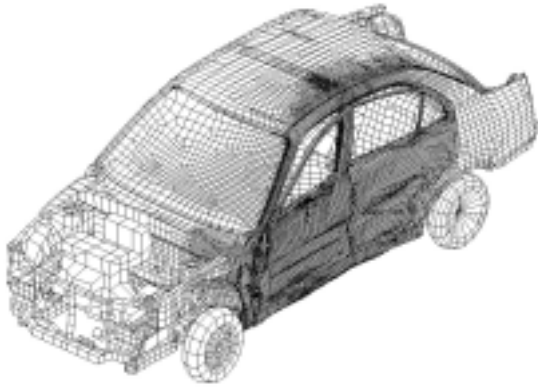


(a)

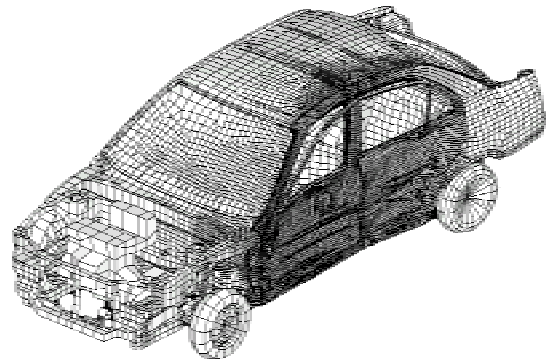


(b)

Fig. 7 Deformed shapes of an auto-body after 35 msec: (a) the conventional material; (b) 60TRIP steel.



(a)



(b)

Fig. 8 Deformed shapes of an auto-body after 70 msec: (a) the conventional material; (b) 60TRIP steel.

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Fig. 2 X, Y, Z, X-Y, Y-Z, X-Z, X, Y, Z

Fig. 9

60TRIP

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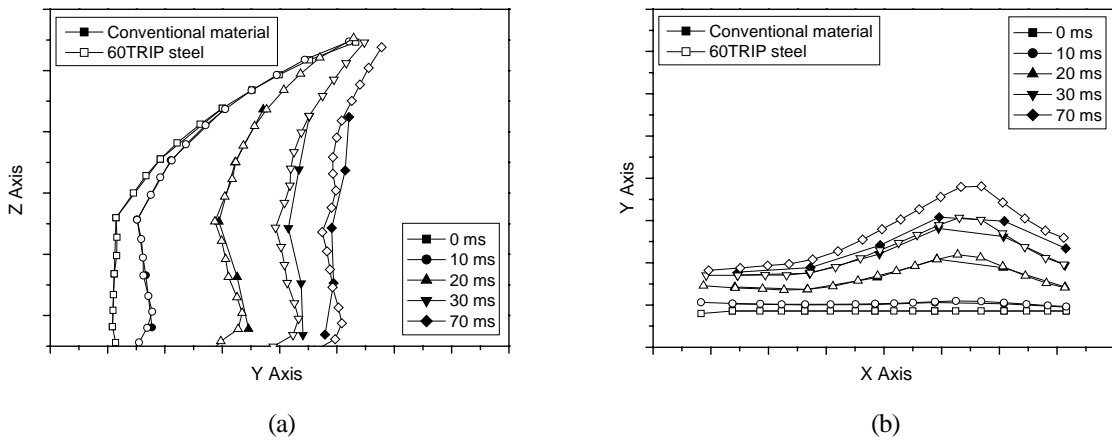


Fig. 9 Deformed shapes of side structures substituted 60TRIP steel for materials of center pillar: (a) center pillar; (b) side sill

. Fig. 9(a)

가 60TRIP

60TRIP

. Fig.

9(b) Fig. 9(a) 60TRIP 가

가 70 msec 60TRIP

. 60TRIP

가

가

가

Fig. 10 60TRIP

. Fig. 10

가 60TRIP

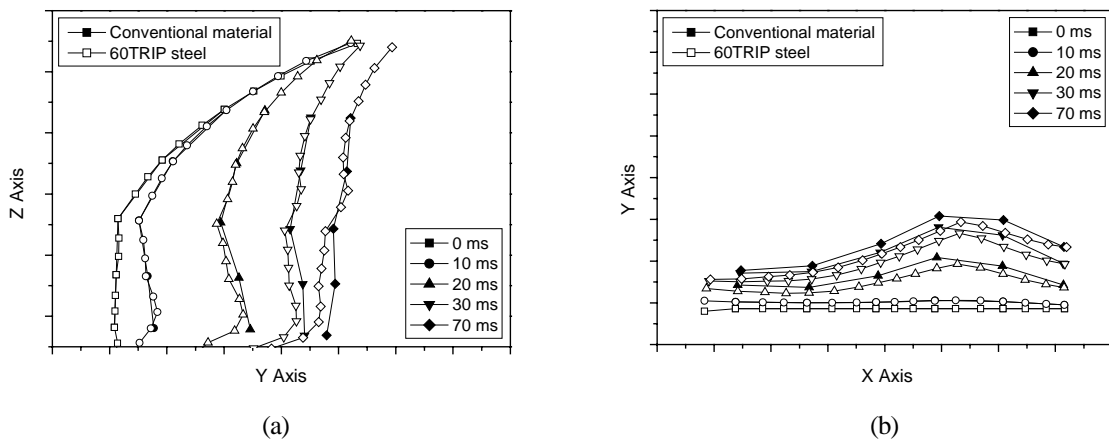
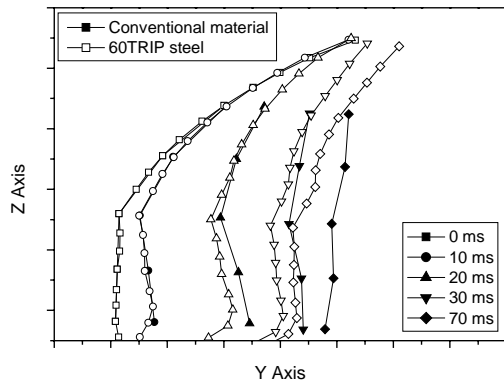
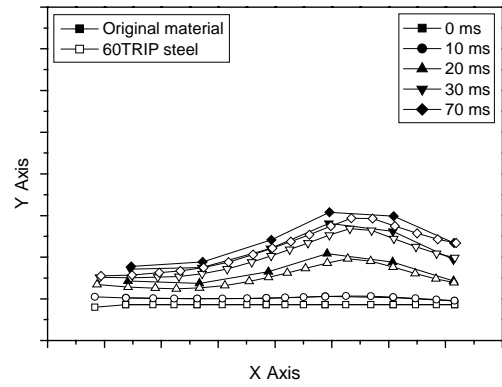


Fig. 10 Deformed shapes of side structures substituted 60TRIP steel for materials of side sill: (a) center pillar; (b) side sill.





(a)



(b)

Fig. 11 Deformed shapes of side structures substituted 60TRIP steel: (a) center pillar; (b) side sill.

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 . Fig. 11  
 60TRIP  
 가  
 ,  
 가  
 ,  
 가  
 가  
 .  
**4.**  
 가  
 FMVSS 214 ,

60TRIP

Cowper-Symonds

가

Cowper-

Symonds

60TRIP

가

60TRIP

60TRIP

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