Aluminium Shear-Link for Seismic Energy Dissipation

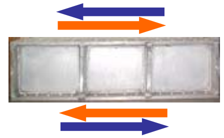
Durgesh C Rai, Department of Civil Engineering, Indian Institute of Technology Kanpur

Introduction

Shear-Yielding of Aluminium

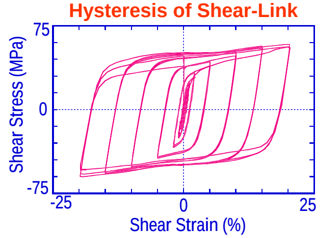
- Ductile with large shearing strains (up to 10%) without buckling or tearing.
- Low yield strength allows thicker web reducing the problem of web buckling
- Shear deformation maximizes material participation in plastic deformation
- Can be used to enhance energy dissipation potential of conventional structural systems

I-shaped Aluminium Panel



Yielded Shear-Link

Hysteresis of Shear-Link

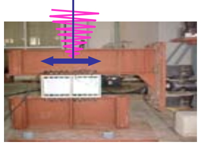


Hysteretic Response

- First yielding at 0.2% strain and stress at 20% strain is 2.6 times the yield stress. No buckling until 10% strain
- Stable response even after buckling due to tension field action formed with the help of transverse stiffeners

Experimental Investigation

24 specimens of three panel aspect ratios and three web depth-to-thickness ratio were tested to obtain key parameters for design of web panel and stiffeners



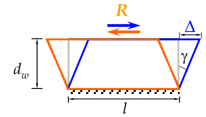
Material Properties

Alloy	Elong. %	Yield MPa	Ult. MPa
6063-T6	15.26	240	261
6063-O	31.08	35	85
1100	16.42	99	112
1100-O	33.32	25	82

Out-of-plane web deformation can be controlled by laterally confining shear web using rubber pads

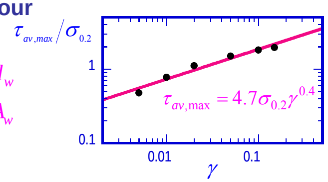
Design Characteristics

Force-Deformation Behaviour



$\Delta = \gamma d_w$

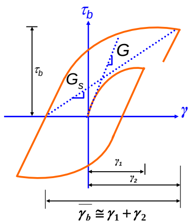
$R = \tau A_w$

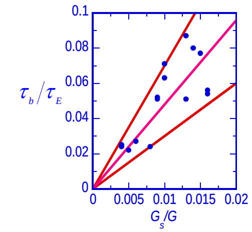


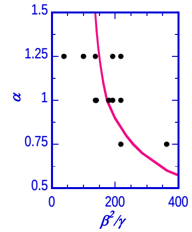
Cyclic web buckling

Critical web buckling deformation angle

$$\bar{\gamma}_b = 4.79\frac{\tau_E}{G} = 12\frac{k_s}{\beta^2} \qquad \tau_E = k_s\frac{\lambda^2 E}{12(1-\upsilon^2)}\left(\frac{1}{\beta}\right)^2 \qquad \beta = \frac{d_w}{t_w}$$





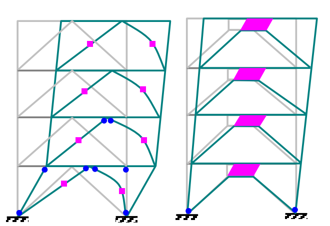


Some Applications

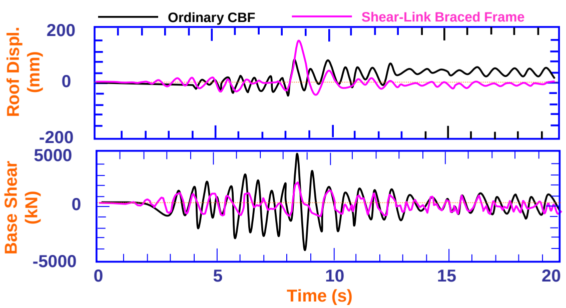
Shear-Link Braced Frame System

Shear-link braced frame system avoids damage to primary members, decreases base shear and inter-storey drift, resulting in reduced non-structural damage

Collapse Mechanism (Miyagi)



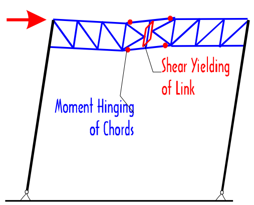
Time History Response (Northridge)

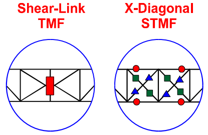


Shear-Link Truss Moment Frames

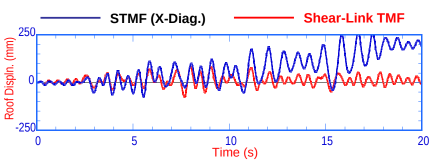
- Strong column - weak girder due to links yielding in vertical shear due to lateral loads, inelastic activities pedominately in links and moment hinging in truss chords for a collapse mechanism.
- Significant energy dissipation in comparison to conventional X-Diagonal STMFs

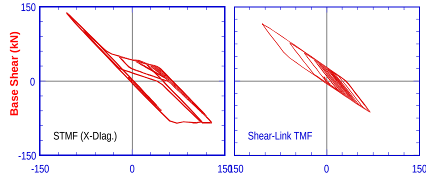
Collapse Mechanism (Pushover Analysis)





Time History Analysis (Miyagi-ken-Oki)





Hysteretic Response (Northridge)

Conclusions

- Aluminium shear-links have very ductile shear-yielding and can dissipate large amount of energy effectively and reliably even at large strains (up to 20% shear strain)
- They have excellent strain-hardening behaviour which helps in avoiding excessive concentration of plastic deformations
- Systems equipped with shear-links showed significant reduction in (i) seismic energy input, (ii) Base shear, (iii) Storey drift
- Shear-links can be easily replaced after extreme earthquakes and can be deployed in existing structures for seismic strengthening

Research Team

Saikat Banerjee, Sachin Jain, Gunturi V S K Prasad, Benjamin J Wallace and staff of structural engineering laboratory at IIT Kanpur

Acknowledgement

Funding was provided by the Ministry of Human Resource Development (MHRD) of Government of India, New Delhi.