Stairs & Ramps

Stairs & Ramps

- Critical structures for egress
- Same issues for steel and concrete stairs
- “Throughout NZ”, every building with stairs requires review of stair/ramp performance
  - *Department of Building and Housing: Practice Advisory 13: Egress Stairs*

Stair collapses and extent of damage

- Forsyth Barr
- Grand Chancellor
- Clarendon
- Heritage Tower

- Many buildings suffered damage to various degrees
  - Mainly the connections between stairs and floors.
- Prior to 1992, interstorey drifts may have been underestimated.

Stairs & Ramps built in at each end

- Act as giant struts or props between floors.
- Change load paths in building
- Fail landings
- Fail the mid-height landings
- Vertical acceleration (not likely)
- Under axial compression –
  - Next slides…

Stairs “built in” between floors

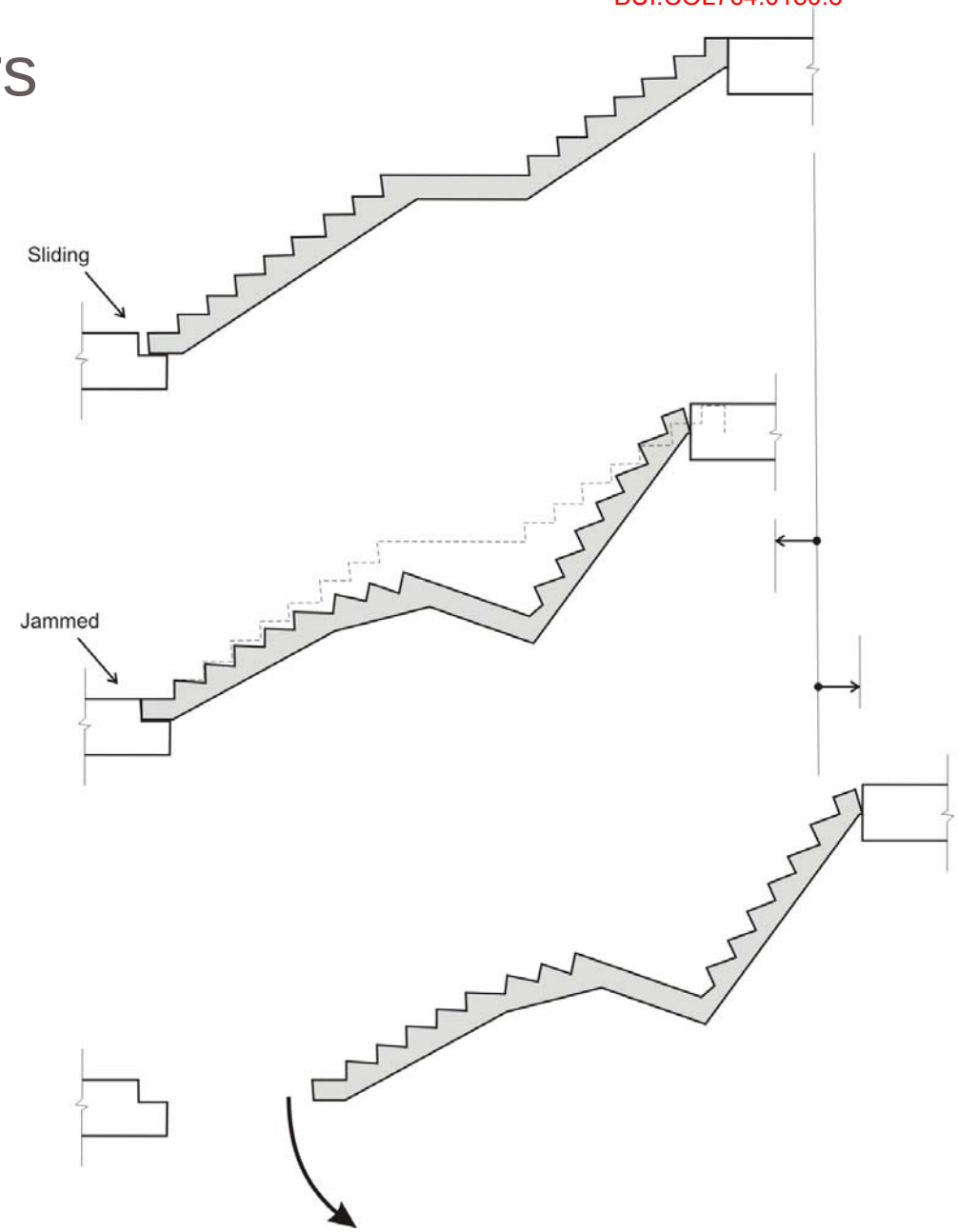

Turkey

Stairs & Ramps sliding at one end

- 3 possible causes of failure:
  - The landing was to small for the interstorey drifts (as designed or construction tolerances used up)
  - The stairs were compressed and axially shortened. On reversing drift, the stairs are pulled off the supports.
  - Vertical acceleration (not likely)

Compressed stairs

- Stair jams & is compressed & permanently shortened
- EQ reverses & pulls stir off the landing




Forsyth Barr
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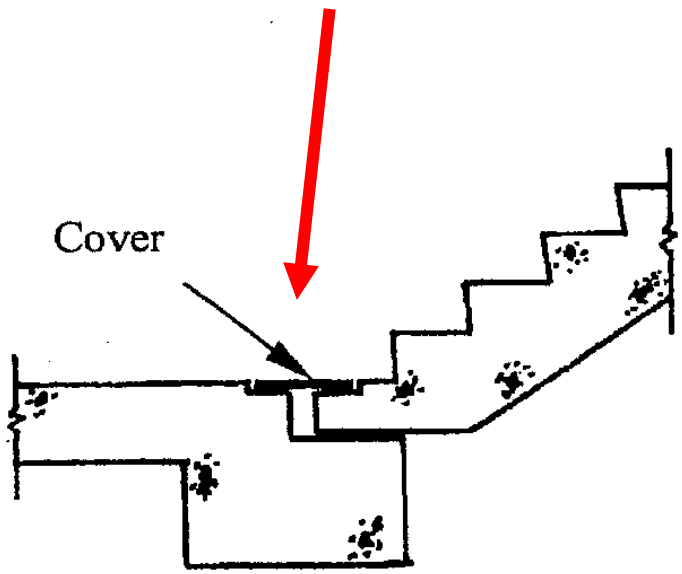
Grand Chancellor


Armoured ledge supports ??

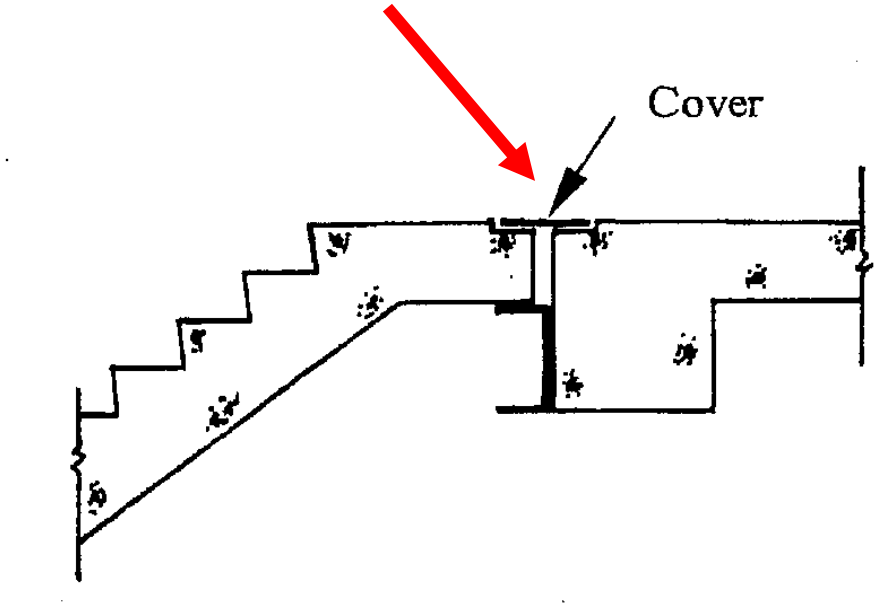
Stairs and Ramps - occasionally

- Stairs and ramps with one end free:

CLEARANCES – not big enough



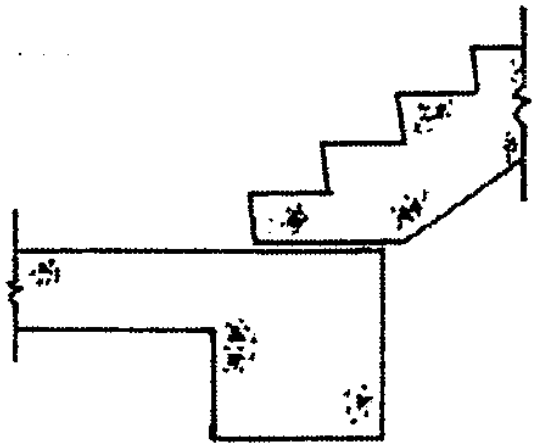
Lower end sliding in side pocket



Upper end sliding in seating member

Stairs and Ramps – more common

- Stairs and ramps with one end free:



Lower end sliding over lower floor

Stairs and Ramps

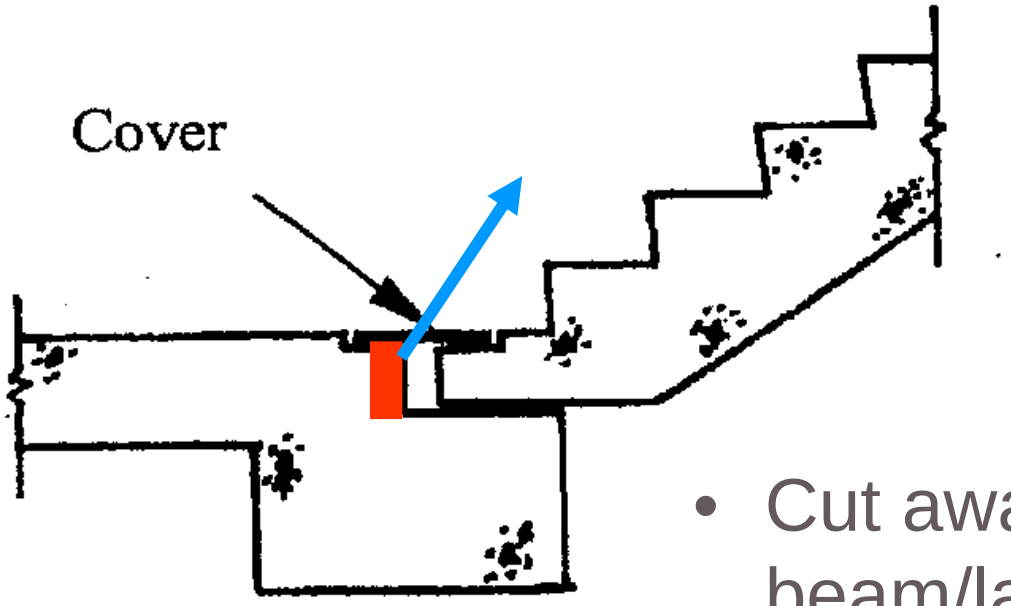
- Stairs and ramps with one end free:
  - Overlap of free end on the landings have to be about 250 mm* in NZ or else when the landings move apart – stair falls.
  - Impact on stair below causes cascading collapse

* Guidance from Engineering Advisory Group for the Department of Building & Housing

Retrofit Concepts

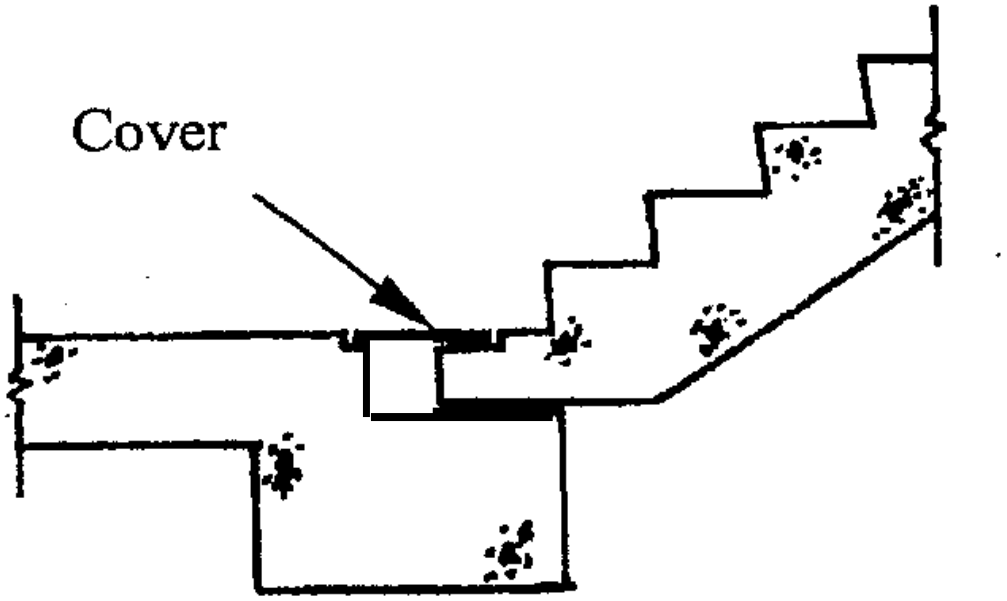
- Replace the whole star and build supports that accommodate sliding
  - Steel
  - For damaged or lost stairs
- Extend the ledge support
- Widening existing clearances
- Put a supporting structure under the stair flight, typically at landings

Retrofit Concepts



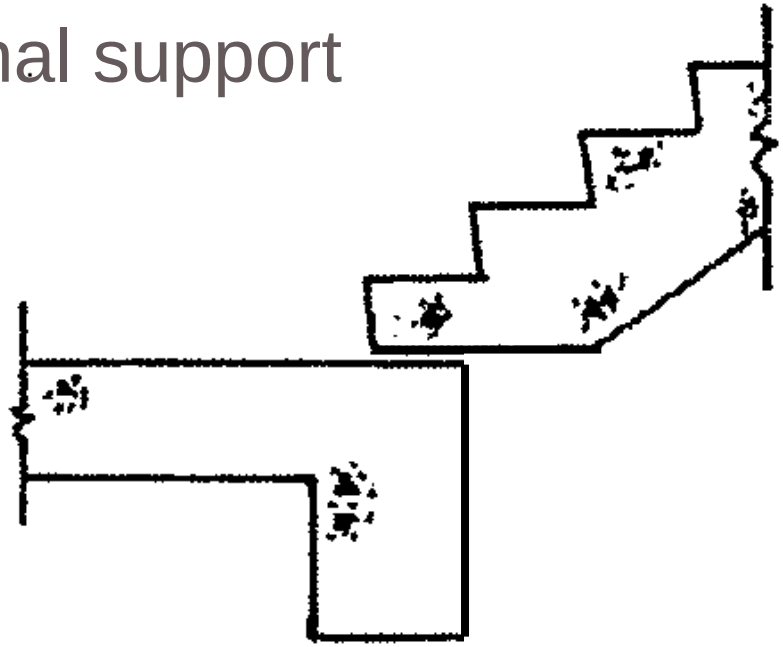
- Cut away part of the beam/landing in front of the stair

Retrofit Concepts



Retrofit Concepts

- Support width too small
- Build additional support



Retrofit Concepts

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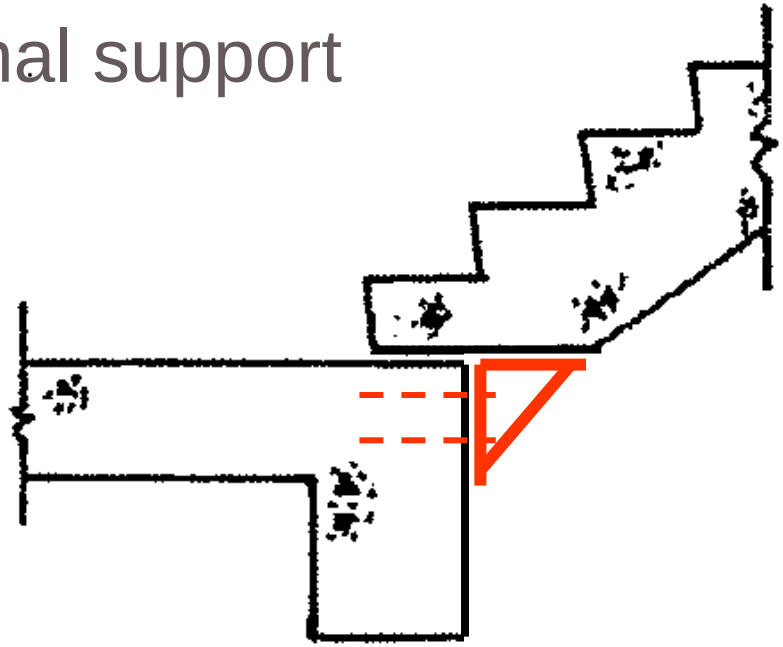
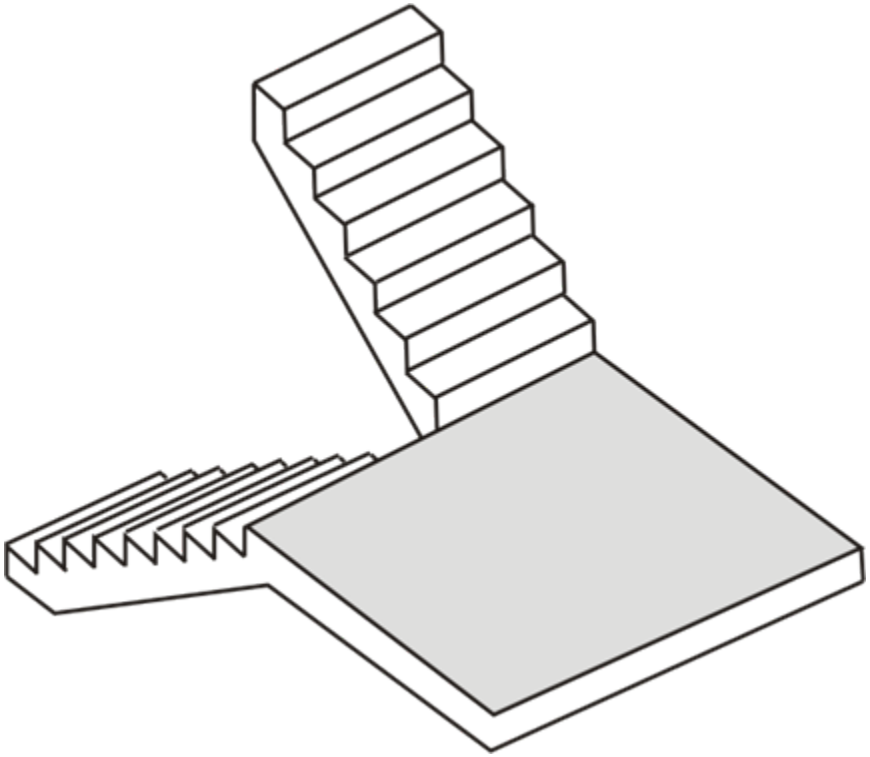
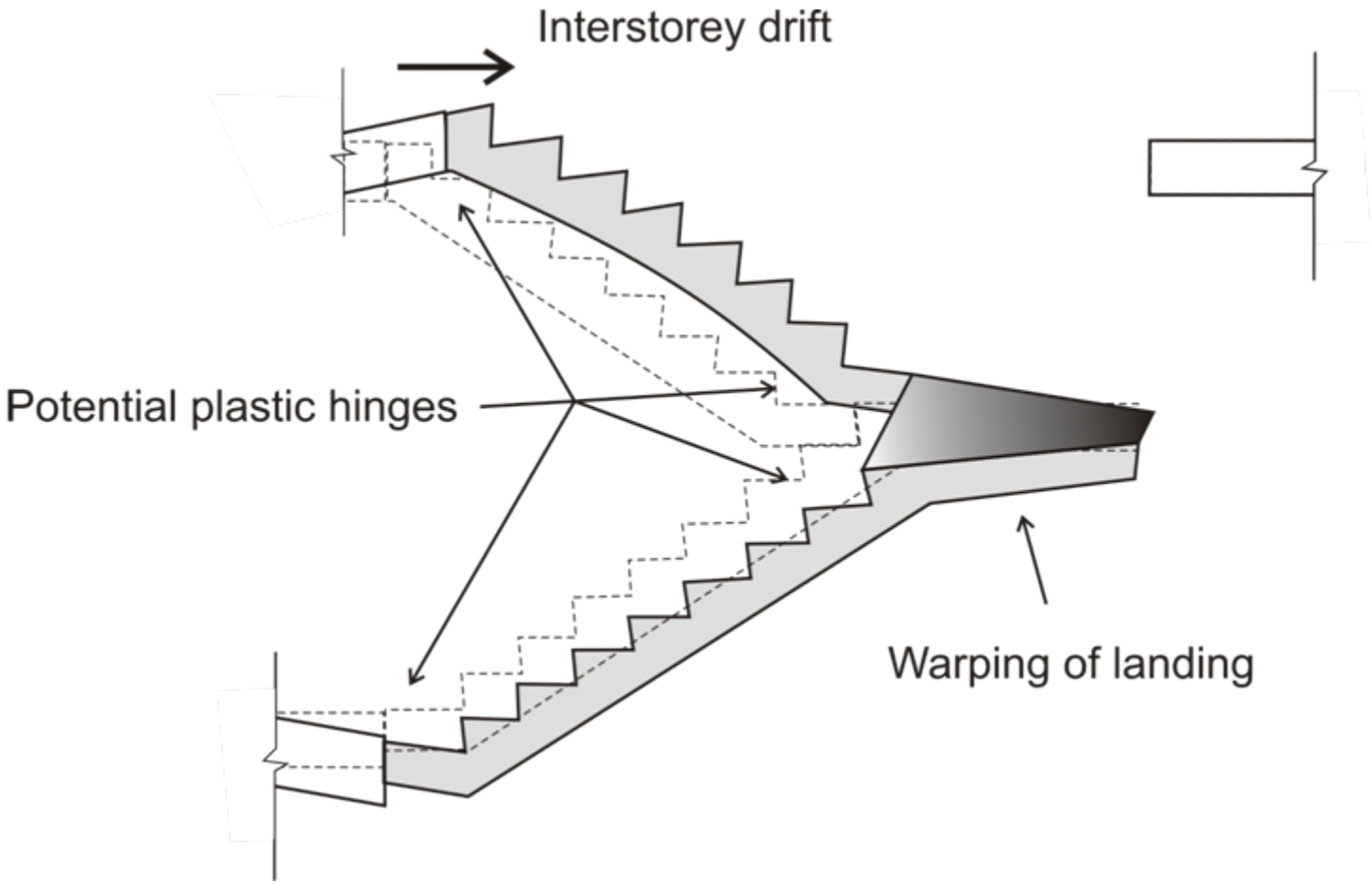


Switchback stairs

- Mid height landing
- Full width, solid

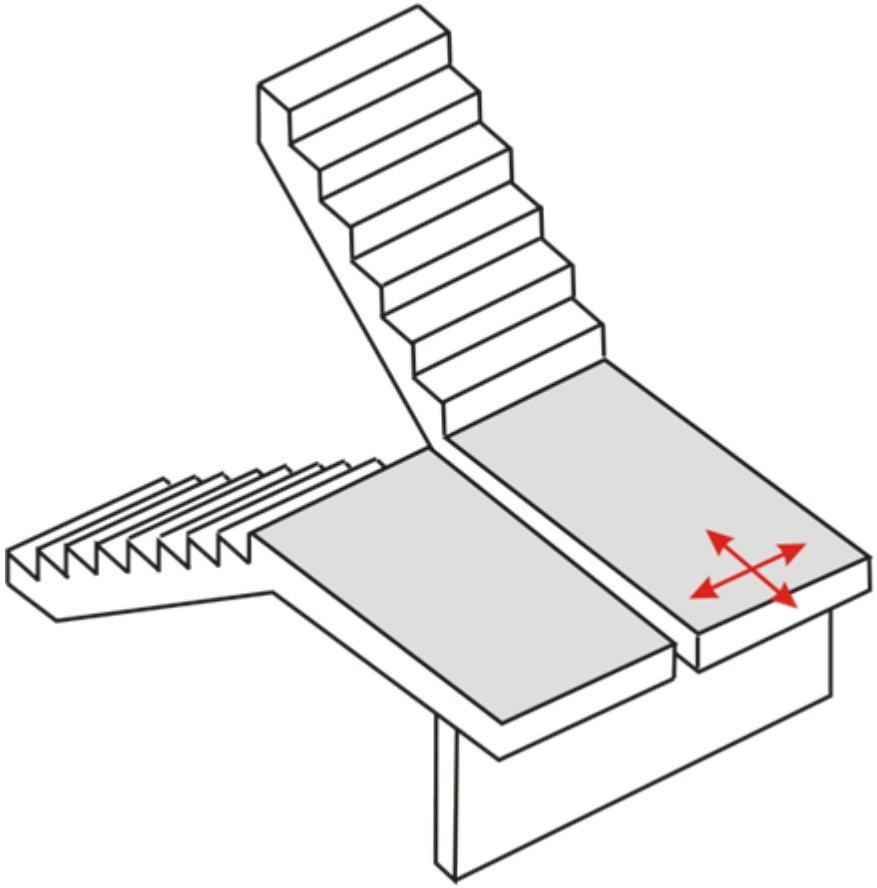


Switchback stairs



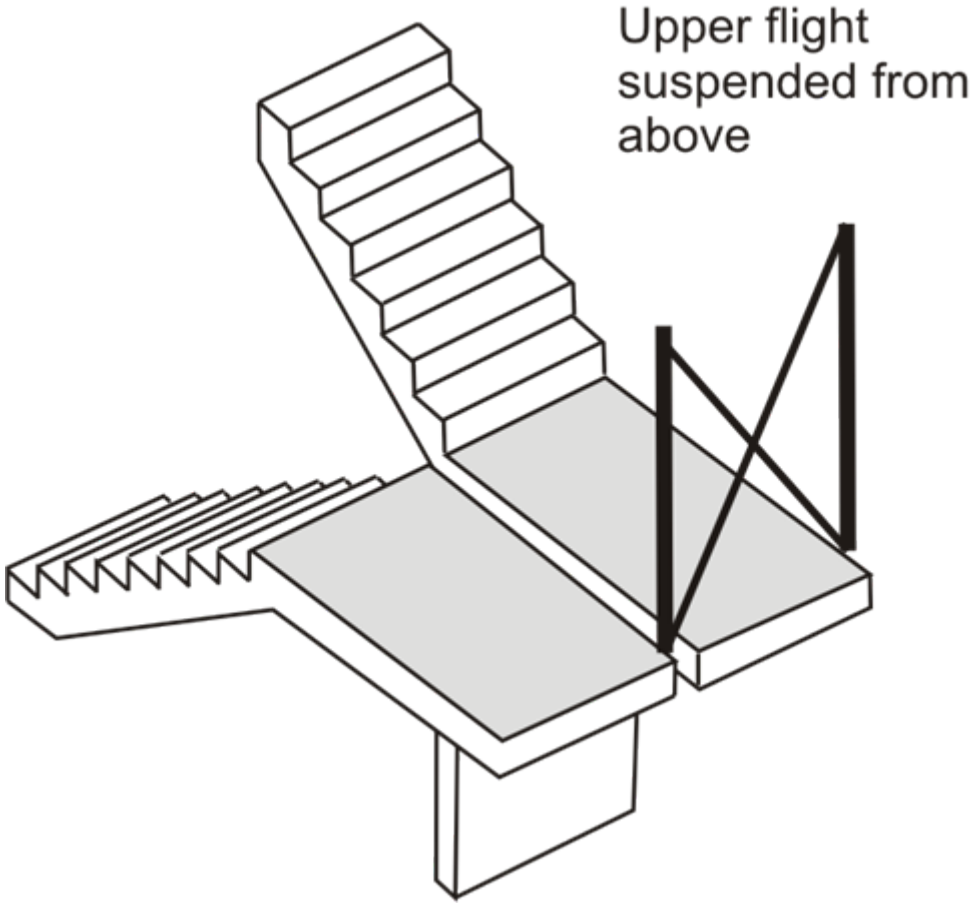
Switchback stairs

- Split landing with top half sliding on the support.
- Lower half supported and braced by the lower floor



Switchback stairs

- Split landing with top half suspended from above
- Lower half supported and braced by the lower floor

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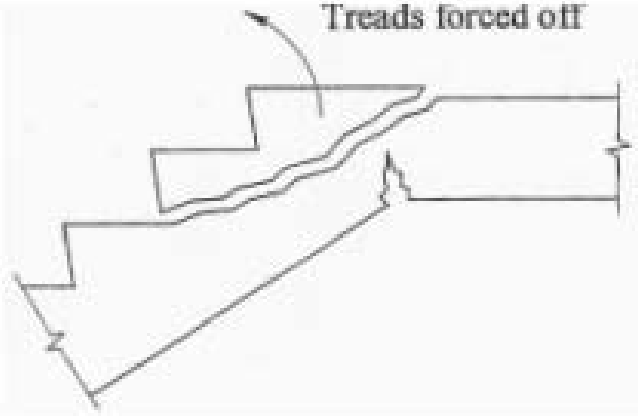
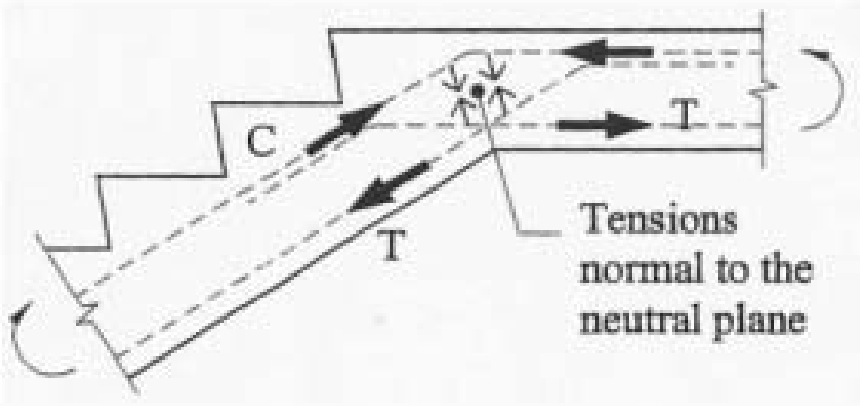
Failure of stair flight to landing connection

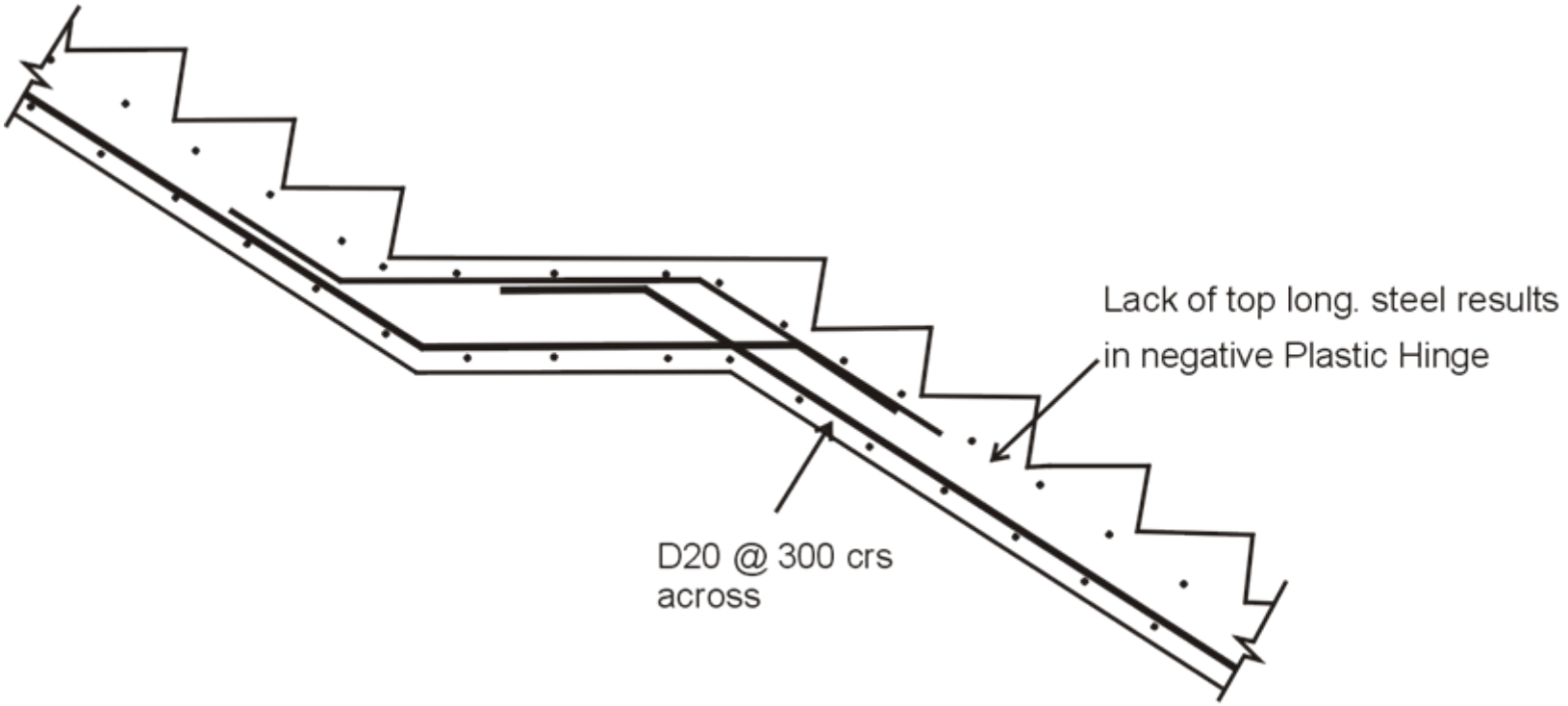
- An issue in concrete stairs
- Dealt with to varying degrees from the late 1980s.





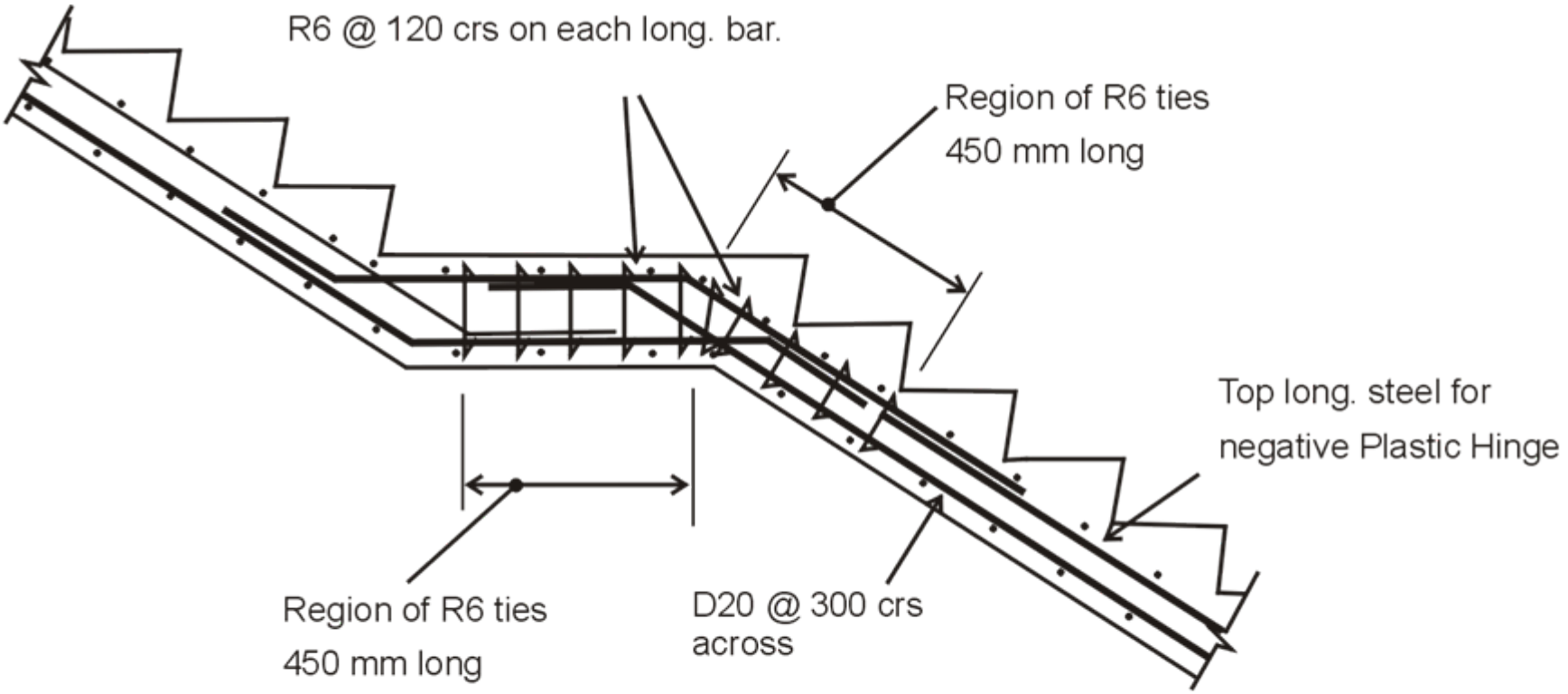
C – compression force

T – tension force (resisted by reinforcement)



(b) Common detail

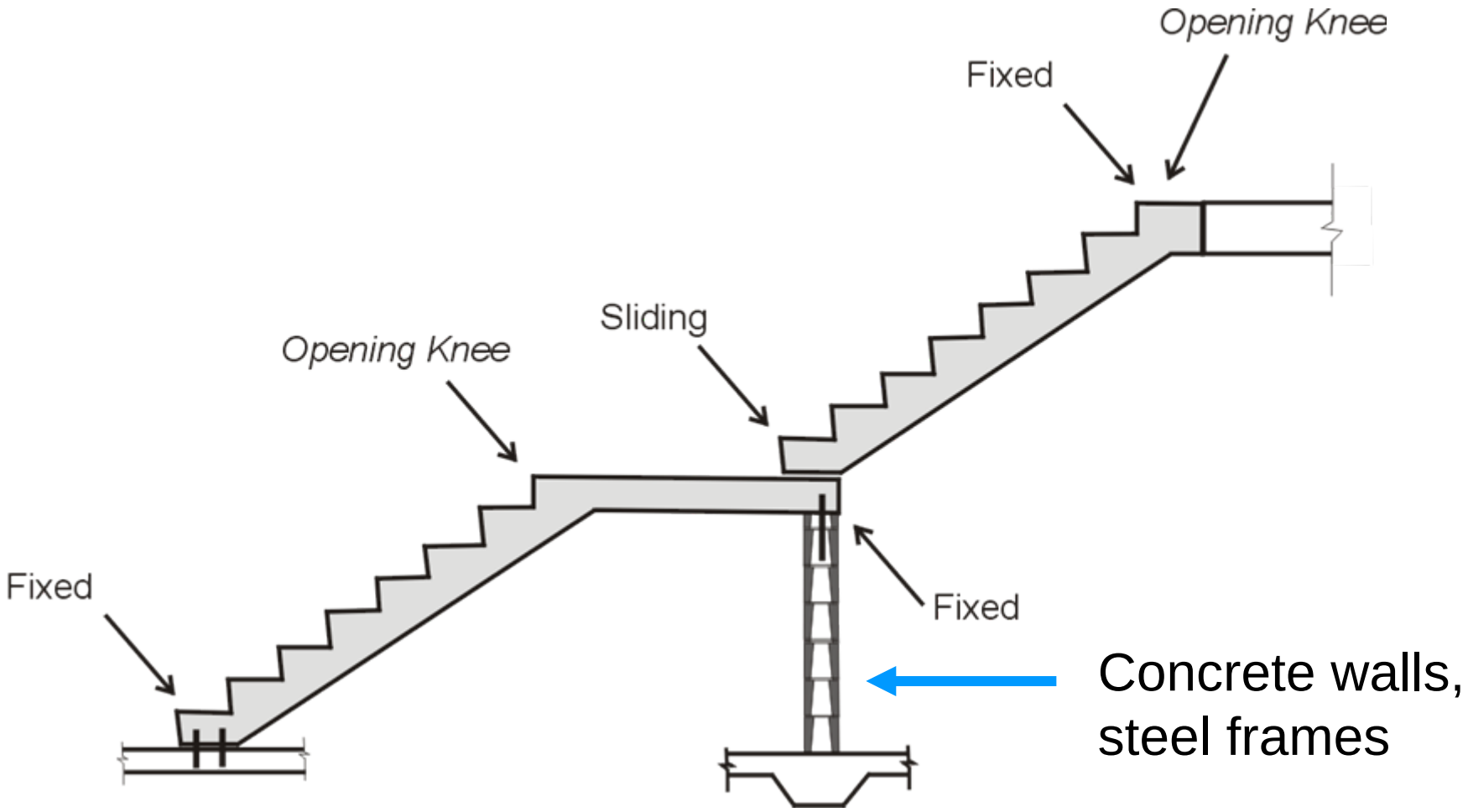
Reinforcement details in Knee: ***Gravity only***.



(a) Recommended detail

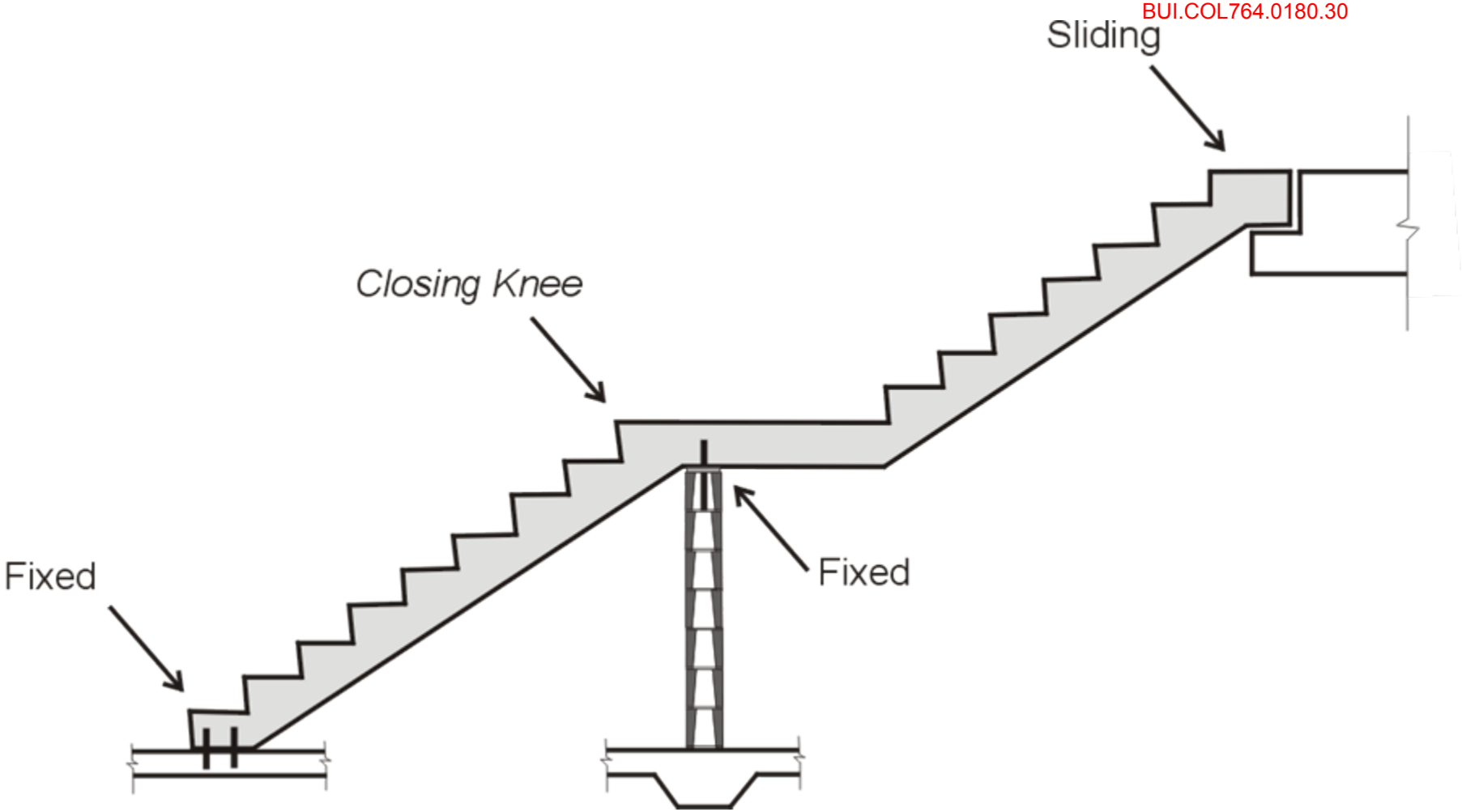
Reinforcement details in Knee: ***Gravity & Lateral Displacement***

(Simmons 2000)



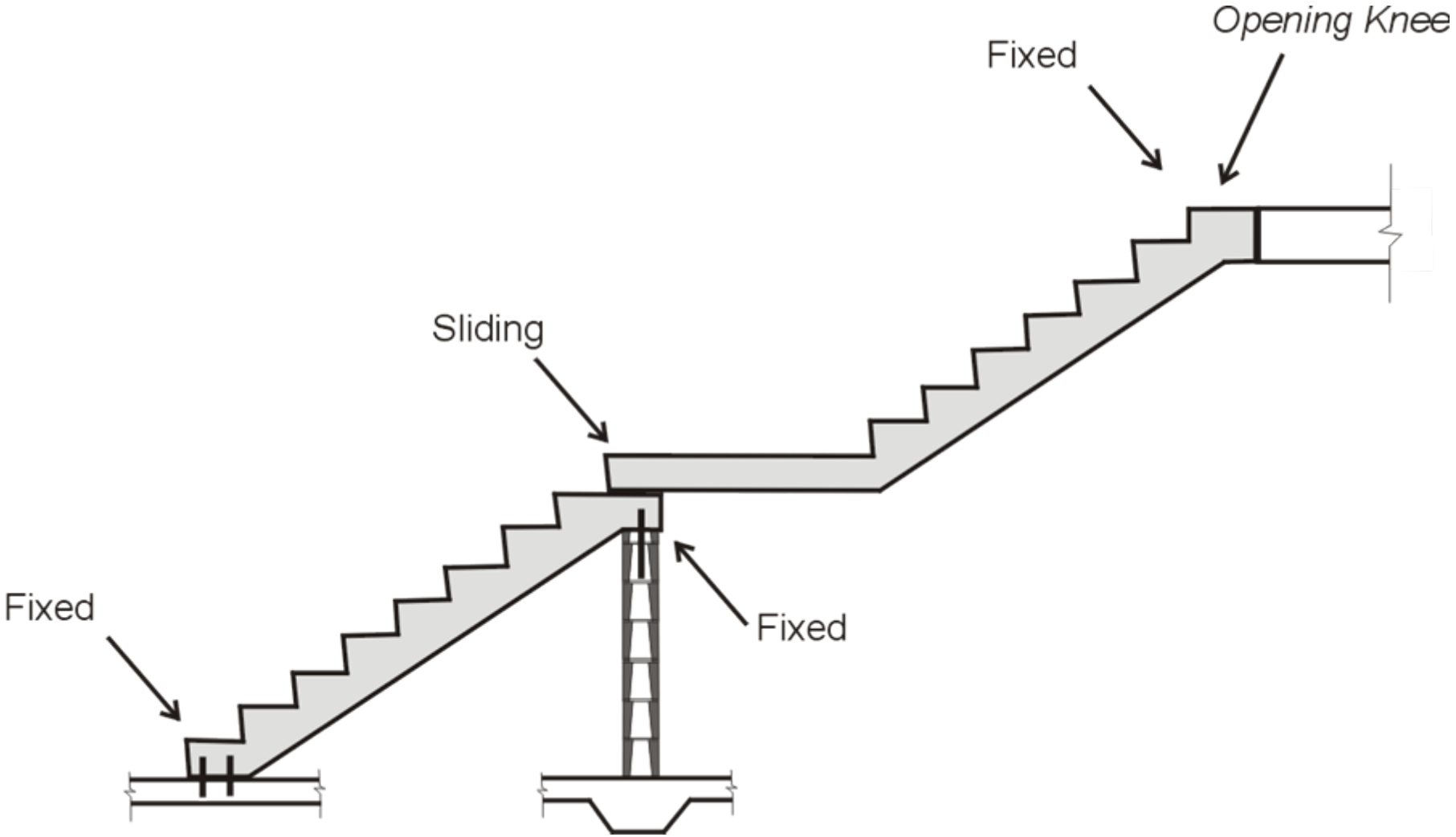
(a) split landing

Intermediate support options.



(b) alternative landing sliding at top.

Intermediate support options.



(c) Alternative split landing

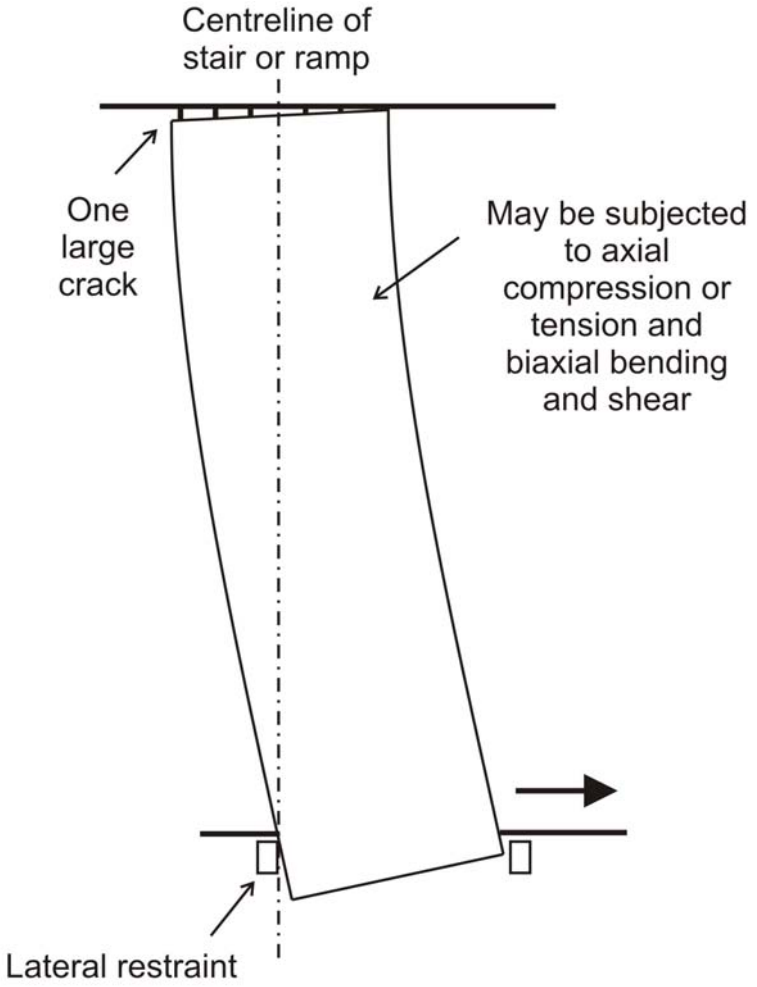
Intermediate support options.

- Support of stairs and ramps mid-height of columns
  - Must be avoided

Structural interference - Short Column Effect
El Asnam Earthquake, Turkey 1980
[EERC archive, UC Berkeley].

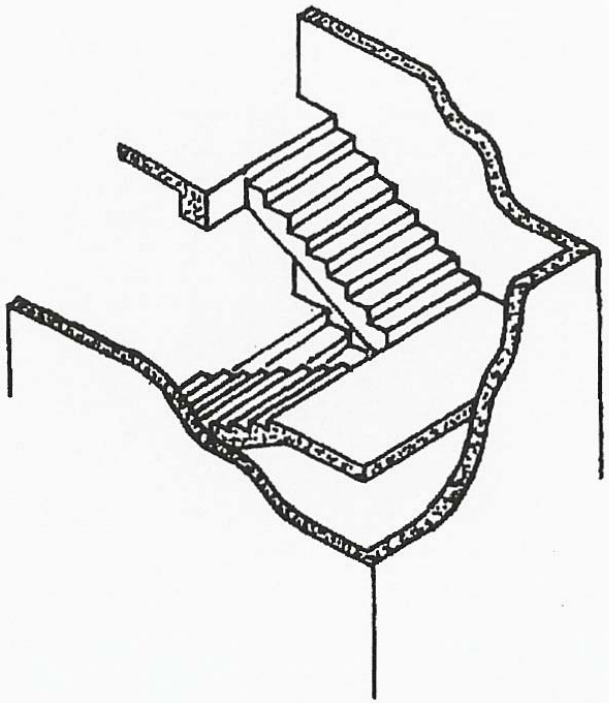
Stairs bending in the horizontal plane

- Bending across the stair
  - Significant damage to connections
  - Needs to be considered by designers



Stairs built in to concrete Core

- Engineers believed these stairs would not have problems.
- Not so, stairs were distressed
  - too a lesser extent



- Questions ?