The Future of Crash Testing

The Descendant of NCHRP

Report 350

History of Crash Testing

- HRB Circular 482 – September 1962
  - One page
  - 4000 pound car
  - 60 mph
  - 7 and 25 degrees
  - “Achieve tolerable lateral deceleration”

History of Crash Testing

- NCHRP 153 – 1974
  - 19 pages
  - 2250 and 4500 pound cars
  - 20 mph to 60 mph
  - 15 and 25 degrees
  - Critical impact points
  - Table of evaluation criteria

History of Crash Testing

- TRB Circular 191 – February 1978
  - 27 pages
  - Refined discussions of soils, test vehicles, and evaluation criteria

History of Crash Testing

- NCHRP Report 230 – March 1981
  - 42 pages
  - 1800 and 4500 pound cars, plus special vehicles
  - 20 mph and 60 mph
  - 15 and 25 degrees
  - Expanded discussions of vehicles, hardware, and test matrices

History of Crash Testing

- NCHRP Report 350 – 1993
  – 132 pages
  – Six test levels with vehicles up to 80,000 #
  – Pick up truck replaces large passenger car
  – 35 kmh and 100 kmh
  – 20 and 25 degrees
  – In metric units

How good was 350?

- 2000 P Pickup was questioned – crash tests run on comparable vehicles:
  - 2000 P
  - Geo Tracker
  - Ford Explorer
  - Standard van
  - Tests at 20 degrees, 100 kmh

Time to update Report 350

- Issues reviewed for updating:
  - Test vehicles
  - Impact conditions
  - Critical Impact Points
  - Efficacy of Flail Space Model
  - Soil type and conditions
  - Test documentation
  - Working width measurement

Time to update Report 350

- Relevance of performance evaluation procedures not fully understood
- There has been little assessment of the effect of upgrading hardware
- Have been technological advances in the last 10 years
- Changes to other specifications

Time to update Report 350

- How do we consider the effect of seat belts and air bags?
- What angles to vehicles leave the roadway?
- How do we account for propensity for rollovers?
- How do barriers perform in the field?

NCHRP Project 22-14

- "Improvement of the Procedures for the Safety Performance Evaluation of Roadside Features"
- King Mak, Roger Bligh, Lindsay Griffin of Texas Transportation Institute
- Completed November 2000

NCHRP Project 22-14

- Objectives:
  - Evaluate the relevance and efficacy of procedures for the safety performance evaluation of highway features
  - Assess the needs for updates to NCHRP Report 350 and recommend strategies for implementing them

Relevance

Are the selected test conditions based on real-world impact conditions?

Will a proposed change in the test guidelines result in a reduction in the severity of crashes?

Relevance

- Major research needed for relevancy:
  - Distribution of impact conditions
  - In-service performance of roadside hardware
  - Performance limits of roadside hardware
  - Relationship of injury severity to impact conditions
  - Relationship of injury severity to crash test evaluation criteria

Assessment of Updating Needs

- Potential updates:
  - Test vehicles and specifications
  - Impact conditions
  - Critical Impact Point
  - Efficacy of flail space model
  - Soil type and condition
  - Test documentation
  - Working width measurement

Potential Updates

- Test Vehicles and Specifications
  - 2000P ?
  - 820C ?
  - New intermediate vehicle?
  - Should specs include additional properties?
  - Heavy trucks?

Test Vehicles and Specs

- 2000 kilogram pickup truck
- Crash analysis shows pickups and SUVs are worst among “light trucks” for crash frequency, severity, and rollovers.
- 2000P (3/4 ton pickup) was shown to be the least stable of the light trucks tested and is a good “surrogate” for this class

Test Vehicles and Specs

- 820 kg passenger car to be replaced
- Geo Metro for 2000 was last car produced in this size range.
- Small car likely to be 1000+ kg sedan
- Terminal and barrier tests would benefit
- Breakaway tests likely would have reduced speed.

Test Vehicles and Specs

- Intermediate test vehicle
- Would be more representative of vehicle fleet, but not more critical
- 1500 kg car would match CEN standards
- Would increase testing costs and may discourage hardware development
- Not recommended for full-scale testing

Test Vehicles and Specs

- Heavy Trucks
- Minor changes in how TL-4, TL-5, and TL-6 heavy vehicles are specified are expected.
- Changes will have no effect on hardware already tested

Impact Conditions

- Impact speed – Increase to 110 kmh?
- Impact angles – 25 degrees too sharp?
- Impact angles – 90 degrees for omni-directional breakaway features?
- TMA test – Should shadow truck be braced?

Impact Conditions

- Raising impact speed from 100 to 110 kmh would cover an additional 2.84% of crashes
- Would mean minor changes to some hardware, complete replacement of others
- We do not know enough to be able to perform an accurate cost-benefit analysis
- Recommend top speed remain at 100 kmh

Impact Conditions

- Impact Angle of 25 degrees into CIP
- Tests with 2000P into barriers has shown problems with stability of the test vehicle
- Three circumstances considered:
  - Barrier length of need
  - Transition from Guardrail to Bridgerail
  - Temporary work zone barrier

Impact Conditions

- 25 Degree impact into barrier length of need
  - Not an impossible scenario
  - Some longitudinal barriers are placed a great distance from the roadway
  - Sufficient alternatives available that have already passed TL-3 using 25 degrees
  - Recommend: do not change

Impact Conditions

- 25 Degree impact into approach transition from guardrail to bridgerail
  - Very rare situation for impact at CIP
  - Transitions usually placed near the roadway
  - Few designs have passed TL-3 at 25 degrees
  - Recommend: Change immediately to 20 degree impact into Critical Impact Point

Impact Conditions

- 25 Degree impact into temporary concrete barriers
  - Rare situation for impact at high angle
  - Temporary barriers often placed near the roadway, sometimes on both sides
  - Some designs have passed TL-3 at 25 degrees
  - Recommend: Change to 20 degree impact into temporary barriers

Impact Conditions

- Small Car impact into Truck Mounted Attenuator
- Truck to be braced to eliminate variables
- Good arguments for keeping brace or for removing
- Recommend removing the artificial constraint of the brace

Impact Conditions

- Omni Directional Breakaway Supports
- It is logical to test omni-directional supports at 0 degrees and 90 degrees
- Recommend increasing upper limit of impact angle from 20 to 90 degrees for omni-directional breakaway supports

Critical Impact Points for Transitions and Terminals

- Test outcome is very sensitive to impact point
- Simulations were run to find the most sensitive location for testing barriers
- New CIPs for transitions were found
- Recommend that work continue on defining methods to establish CIP for each device

Flail Space Model

- Links crash tests to potential for human injury
- Idealizes occupant as an “unrestrained lumped mass”
- Upon vehicle contact with test article, vehicle begins to slow, but occupant doesn’t
- “Occupant Impact Speed” at 2 feet

Flail Space Model

- Once occupant has contacted vehicle interior, he will experience same decel as test vehicle, or “ridedown acceleration.”
- The highest average ridedown acceleration is measured over a 10 ms time span
- Occupant impact speed and ridedown accel are calculated from vehicle position after impact

Flail Space Model

- Europeans use similar models:
  - THIV Theoretical Head Impact Velocity
  - PHD Post Impact Head Deceleration
  - ASI Acceleration Severity Index
- Still just a mathematical model for what happens in a crash

Instrumented Crash Test Dummies

- Actual forces and accelerations on occupants can be measured with a dummy
- Various sizes and ages available
- Side impact dummy available
- Dummies are expensive and must be calibrated before each test

Instrumented Crash Test Dummies

- Repeatability is very sensitive to position of dummy at impact – may require seat belts
- Vehicle interior can have a significant impact on dummy response
- Dummies would have to be modified for oblique impacts
- Dummies not yet practical for safety hardware testing

Crash Victim Simulators

- Advances in biomechanics and computer modeling have made occupant models much more accurate.
- Articulated Total Body Model (ATB) was developed from research at CALSPAN and Wright-Patterson Air Force Base
- Must also model vehicle interior surfaces

Crash Victim Simulators

- Mathematical Dynamic Model (MADYMO)
- LS-DYNA Finite Element Program
- None are yet practical for use in simulating occupants in hardware crashes
- Recommendation to use European version of flail-space model in this update of 350

Soil Type and Condition

- NCHRP Report 350 has “Standard Soil” and “Weak Soil”
- Use of Weak Soil limited to certain breakaway supports
- Soils meeting the sieve specifications may still vary widely in strength

Soil Type and Condition

- Recommendation:
  - Keep Strong and Weak soil specifications
  - Test soils used by each test agency
  - Establish acceptable range of soil strength
  - Add performance-based specification to 350 update that will require static testing of soil strength for each crash test and determination of moisture content.

Test Documentation

- Some test reports lack:
  - Adequate description of test article and how it was constructed
  - Information on the components used in construction of the test article
  - Details of soil type and condition
- Some test articles do not match drawings

Test Documentation

- Recommend:
  - Include CAD drawing of test article
  - Report significant deviations or variations from drawings
  - Report any unusual items pertaining to installation that could affect performance
- These are within scope of Report 350 today

Test Documentation

- Other potential refinements:
  - Assessment of windshield damage
  - Assessment of occupant compartment deformation
  - Report should assess pass or fail criteria
  - Harmonize format with CEN standards
  - Other measures to assess repeatability

Working Width Measurement

- Similar to "dynamic deflection"
- Working Width Measurement : Distance between the side facing the traffic before impact of the test barrier and the maximum dynamic lateral position of any major part of the barrier or the vehicle.
- Recommended to be added

Thank You!

- Nick Artimovich
- Federal Highway Administration
- (202) 366-1331

- FHWA Office of Safety Web Site:
- http://safety.fhwa.dot.gov