3.3.1 New Structures

Exposed supporting elements that can be hit by errant vehicles or trains shall be designed for the CT impact load. Generally this will include pier columns, and non-redundant through type superstructure elements, such as thru trusses or thru arches. Due to the improbable coincidence of other loads, the analysis may be limited to the impact load and dead loads with a load factor of 1.0. (C1)

Concrete columns and compression members with a gross area greater than 2600 square inches with a minimum cross section thickness of 42 inches with minimum bonded well distributed flexural or column reinforcement in each exposed direction and with minimum stirrups or column tie transverse reinforcement need not be checked for CT loads. (C2)

Small members shall be checked for adequate load capacity. The minimum shear strength along the member shall be at least equal the applied shear from the CT load but not less than 160 kips. The shear strength need not exceed 400 kips at any point. Plastic analysis of the member may be used. (C3)

C1: While this does not happen often, collision from ships, trains and trucks is the second most common cause of bridge collapse.

C2: Concrete columns with an area greater than 2600 square inches meeting minimum longitudinal and transverse reinforcing requirements will normally have sufficient strength to resist the 400 kips collision load currently specified.

C3: Concrete columns and compression members with a cross section of less than about 450 square inches can not easily be designed to resist a 400 kips collision load. Larger concrete members with a cross section of less than about 1070 square inches may be capable of resisting a 400 kips collision load if the geometry is favorable (short members with fixity top and bottom) and they are heavily reinforced in flexure and shear. Concrete members with a larger cross section but less than 2600 square inches will normally need either a favorable geometry or greater than the minimum amounts of transverse and longitudinal reinforcing otherwise required.

The minimum shear capacity of 160 kips reflects shears that may occur very transiently due to inertial resistance of the column prior to plastic hinge formation. For example a pier restrained against translation and moment at the bottom, but unrestrained at the top would have a shear of 400 kips below the impact point and 0 kip above in a static analysis, but in the first instants of impact the inertia of the upper parts of the column and perhaps pier cap would provide lateral restraint above the impact point with an instantaneous distribution of the impact force closer to 240 kips below and 160 kips above the impact point.

Plastic analysis allows simple analysis by analyzing a non-redundant member with the moments at the top, bottom, and impact point set at the member flexural

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In unusual circumstances where members sufficiently strong to survive the impact load are impractical, the structure may be alternatively checked for adequate redundancy to resist collapse with the loss of the members that have inadequate strength to resist the impact load. This is done by analyzing the structure with the inadequate members missing with the structure subject to a load of at least 1.0 DL and 0.5 LL+I. Plastic analysis may be used. (C4)

For through type structures, such as thru trusses or thru arches, a 54 inch tall TL-5 barrier may be used to protect the through members.

3.3.2 Temporary Works

Temporary falsework towers that are within 30 feet of through traffic shall be able to resist a 400 kips impact load without collapse of the supported structure, or shall be protected by concrete barriers or rigid steel barriers with a minimum of 2 foot shoulder. The barriers shall have a minimum of 2 foot clear zone of intrusion from the tower to the traffic side top edge of the barrier. For speeds over 35 mph the barrier shall either be at least 54 inches tall or have 10 feet available for the zone of intrusion. If the speed is expected to be over 45 mph, or the ADTT exceeds 10,000 vehicles per day, or the through traffic is railroad or light rail traffic, then the barrier shall have the strength, stability and geometry required for a TL-5 barrier, except for cases where loss of the temporary tower would not cause collapse of the supported structure. (C5)

Guardrails protecting falsework towers or piers shall continue at full rail height for at least 30 feet each way from the tower and shall be configured with full height rigid barriers to prevent running around the rail end and hitting the tower from the opposite side of the rail. If ends transition into lower approach rails rather than crash cushions or barrels, that approach rail shall be a rigid rail type (such as Type 7) and shall not end for at least an additional 170 feet. (C6)

strength at those locations. Shears are found by the change in moments divided by distance between points.

Concrete filled steel tubes may be capable of resisting the 400 kips collision load with smaller sections than are required for concrete columns.

C4: A number of structures have survived the failure of columns, entire piers, or seemingly critical truss members without collapse. However, there is usually considerable difficulty to repair damage and the structure normally needs to be out of service for a considerable time for repairs, an issue for important structures. In addition, analysis of the alternate load paths can be difficult and lacks code guidance. Half the unfactored LRFD liveload approximates the liveload that can be expected within a slow response time up to a week.

C5: This controls the risk of collapse onto the interstate or railroad from collisions from errant vehicles. Falsework towers have been designed to resist collision loads in the past, although the typical reusable shoring is not capable of resisting collision loads of this magnitude. Eventually taller portable barrier schemes may be developed to protect these structures at low cost. Note that construction zones and lane shifts may increase the risk of errant trucks.

C6: This keeps any truck away from the temporary falsework and protects falsework towers from large debris from a head on impact between a vehicle and the end of the special barrier and prevents a vehicle mounting and straddling a barrier from reaching the tower or pier.

If the top of the barrier is smooth the length required to bring a high speed truck straddling the approach rail to a halt would be much longer. Type 3 barriers do not seem to slow straddling trucks much, but do lead the truck into the column. Methods for roughening the top of the approach rail should be considered.

3.3.3 Existing Structures

When evaluating bridges for rehabilitation that may result in a potentially long remaining life, consider the risk of collapse or serious structural damage from future collision loads. If that risk is high consider adding mitigating measures such as strengthening columns or at risk members or improving approach rails protecting at risk members. (C7)

Placing a barrier in front of a pier or other obstacle should not in itself be considered as providing adequate protection. The barrier heights, offset distances, and transition guardrail treatments given in Subsection 3.3.2, the AASHTO specifications, and AASHTO Roadside Design Guide must be considered when evaluating risk of collapse or serious structural damage. Barrier height and offset distance should be optimized to help prevent high center of gravity vehicles from leaning over the barrier and into the pier or obstacle. Transition guardrail details should be optimized to help prevent vehicles from riding up on top of the barrier, or getting behind the barrier, and traveling into the pier or obstacle. (C8)

C7: It may be relatively economical and practical to strengthen a structure by adding or strengthening members, or providing or upgrading protection to prevent impacts if this work is concurrent with other widening or rehabilitation.

There is a Texas research project Funded, Contract/Grant Number: 9-4973, but not underway at this time on the issue of the CT load.

There is additional discussion and guidelines under development on this topic by CDOT Staff Bridge Branch.

C8: In addition to vehicles riding up on top of barriers, high center of gravity vehicles lean over the top of barriers. See the discussion in the *AASHTO Roadside Design Guide, 3rd edition, 2006, article 6.4.1.8, Concrete Barrier*.

The CDOT and other DOT’s place barrier around pier walls and columns to protect them from traffic impacts, but the presence of the railing does not guarantee that the substructure elements won't be damaged. In the last couple of years there have been several examples of these impacts on Colorado's highways:

Structure H-02-EM, which carries County Road 26.5 over I-70 in Grand Junction, was impacted by a tanker truck in August of 2007. From the Type 3 transition guardrail the truck rode up on top of the concrete barrier and into the pier taking out one of the two pier columns. See photos 3.3-1 & 3.3-2.

Structure L-18-BA, which carries S.H. 45 over I-25 south of Pueblo, was impacted by a tractor-trailer in December of 2005 where the median barrier actually launched the truck into the outside pier column. See photos 3.3-3 & 3.3-4.

Structure F-19-AH, which carries a ramp to S.H. 36 over I-70 near Strasburg, was impacted by a tractor-trailer in March of 2008. In this case, the truck went off the road behind the railing to take out the exterior column. See photo 3.3-5.

Photo 3.3-1

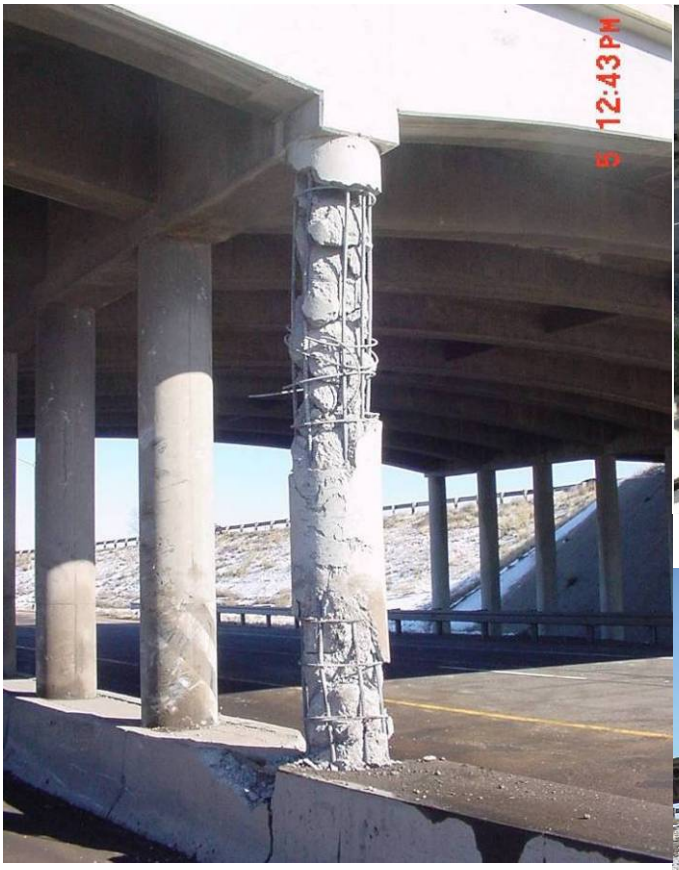

Photo 3.3-3

Photo 3.3-2

Photo 3.3-4

Photo 3.3-5