Concepts and Design Recommendations for Safer Luminaire Supports

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ABRIDGMENT

•FULL-SCALE tests were conducted to evaluate breakaway bases for luminaire supports. A survey of the state highway departments was conducted to determine the base concepts being used or considered for use. This study revealed that there were four basic base concepts: (a) frangible aluminum and progressive shear inserts, (b) conventional cast aluminum shoe bases, (c) flanged aluminum shoe with integral riser, and (d) slip bases. The results of eight full-scale tests are given in Table 1.

The safety offered by the bases was evaluated on the basis of (a) change in vehicle kinetic energy, (b) vehicle deformation, (c) direct damage assessment, and (d) change in velocity. The ranking of the four concepts in the order of most severe to least was as follows:

1. Cast aluminum shoe base,
2. Progressive shear transformer base,
3. Cast aluminum transformer base,
4. Triangular slip base.

A mathematical model, which was verified by a full-scale crash test, was formulated to simulate the impact response of the vehicle and support. The results of a comprehensive parameter study and the full-scale tests were used to develop recommendations for the design of safer luminaire supports. The recommendations follow:

1. The base fracture energy (energy required to fracture or disengage the base) of any base under consideration should be determined by reliable means (laboratory tests or analytical means).
2. Aluminum insert bases and other bases made of frangible material (recommendation based on current designs) should be constructed so that the vehicle bumper contacts the base instead of the supported shaft. Automobile standards should be consulted to determine bumper heights.
3. The lowest base fracture energy that is consistent with static and wind strength requirements should be used.
4. The initial tension or preload and the clamping bolts of slip-type attachments should be high enough to balance the static loads and also have a suitable factor for wind loads. Provision should also be made to prevent joint "walking."
5. Concrete foundations should be constructed so as to be level with the surrounding ground surface. The ground clearance of most modern vehicles is approximately 6 in.
6. The supported shaft must have sufficient strength to resist crushing or denting in the vehicle contact area when it is supported by a slip-type base. Existing ASTM A-245 Grade C, 11-gage shafts appear to be adequate.
7. Bases having properties that are dependent on their orientation should be positioned so that the direction of least resistance will coincide with the most probable vehicle approach angle. This is of primary importance in low-velocity collisions. Due consideration should also be given to aesthetics.

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TABLE 1

SUMMARY OF TESTS

Concept	Test No.	Base Material	Shaft	Vehicle Wt. (lb)	Veh. Velocity, Film (mph)				t_{lc} (sec)	Vehicle Def. (in.)	Vehicle Damage ($)
					V_i	V_f	ΔV_f	ΔV_{1c}			
Frangible insert base	1	Cast Alum. B-108-62T-S(607) A(T-6)	35 ft Steel (straight)	3580	43.8	36.7	-7.1	-5.6	0.069	14	397
	2	Cast Alum. A356-T6	35 ft Steel (straight) 40 ft M. H.	3340	39.5	32.5	-7.0	-5.7	0.140	16	459
Progressive-shear base	3	201 Stainless	35 ft 5 in. S. Steel (straight) 40 ft M. H.	3880	43.1	35.3	-7.8	-6.5	0.167	16	427
	4	Galvanized Sheet Steel	35 ft Steel (straight) 40 ft M. H.	3620	44.0	37.3	-6.7	-5.9	0.080	15	427
Cast aluminum shoe base	5	Cast Alum. A356-T6	37 ft Alum. (straight) 40 ft M. H.	3700	37.7	28.3	-9.4	-9.3	0.098	20	838
	6	Cast Alum. A356-T6	37 ft 2 in. Alum. (straight) 40 ft M. H.	3580	40.8	33.7	-7.1	-6.0	0.105	17	484
	7	Cast Alum. A356-T6	28 ft Alum. (straight) 30 ft M. H.	3820	42.2	38.2	-4.0	-2.4	0.075	11	382
Slip base	8	Steel A441	35 ft Steel (straight) 40 ft M. H.	3640	40.6	37.7	-3.3	-1.9	0.172	9	not available

Notes: V_i = vehicle velocity at contact (mph)
V_f = vehicle velocity at rear tapeswitch set (mph)
ΔV_{1c} = change in vehicle velocity at loss of contact (mph)
ΔV_f = change in vehicle velocity at rear tapeswitch set (mph)
t_{1c} = time after impact when contact was lost
All supports used 50 lb simulated luminaires; all vehicles were 1958 Fords.

8. The shaft should be as light in weight as possible, and the base fracture energy a minimum for all cases where the probability of low-velocity collisions is high.
9. Supports that have mounting heights greater than 40 ft and bases with fracture energies greater than 9000 ft-lb should be considered with caution since they may produce hazardous conditions in low-velocity collisions.

Curves were derived that can be used to determine the vehicle and support response due to a collision. Curves for 30- and 40-ft mounting height steel and aluminum supports struck by vehicles of 2500, 3500, and 4500 lb were prepared. These curves are entered with vehicle collision velocity and base fracture energy of the support base and are used to determine the change in vehicle velocity and the relationship of the pole to the vehicle. Other curves were formulated that can be used to determine the maximum translation of the support toward the roadway.

The design recommendations and curves can be used to check for the safe performance of luminaire supports. Variations from the analytically obtained values could occur in actual collisions due to conditions different from those assumed. However, a thorough knowledge of the principles of breakaway luminaire supports and prudent application of the design recommendations will result in the design of safer luminaire supports.

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