Technical Note

BELGARD
PAVES THE WAY™

DESIGN CONSIDERATIONS FOR CONCRETE PAVER SURFACED ACCESS LANES - SUBJECTED TO FIRE TRUCK LOADING

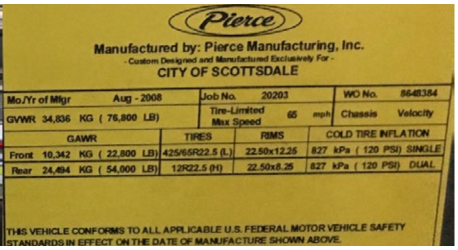
A common question posed by design professionals is the ability of interlocking concrete pavers (ICPs) and permeable interlocking concrete pavers (PICPs) to withstand fire truck loading. This is due to the relatively large axle weights they exert along with the fact that fire trucks are critical service vehicles that must be able to access sites in emergency situations.

In terms of structural design for entry, access lane and roadway applications, pavements must be designed to resist rutting, bearing capacity of the supporting pavement system and resistance to repeated axle load applications. Pavement design procedures typically utilize information which describe the strength of the subgrade soils, axle loadings and frequency, and strength of the various layered pavement components. The actual design procedures for flexible and rigid pavements are well documented in Civil Engineering texts with ICPs & PICPs well recognized to behave and follow the design procedures set forth for “flexible” pavement design. References for ICP and PICP pavement design are provided in this Technical Note (AASHTO 1993, ASCE 2016 & 2018, Caltrans 2016).

While not a comprehensive primer on pavement design, the focus of this report is to demonstrate that ICP and PICPs are not adversely affected by heavily loaded vehicles and are suitable for use in vehicular areas exposed to fire truck loadings. The primary discussion herein will focus on fire truck loadings on ICP/PICP systems as they relate to:

- **Design ESALs applied to the pavement system.**
- **Fire truck wheel and axle loads relative to the strength of the paver**
- **Point loads that may occur when the stabilizer outriggers are in place.**

Because this document focuses on fire truck loading, data on a typical heavily loaded fire truck was obtained for a "ladder truck" used by the City of Scottsdale, AZ. The vehicle chosen is one of the heaviest vehicle in a typical Fire Department’s fleet and is considered on the upper end of the fire vehicle loading spectrum. A few images of the vehicle and its characteristics are provided below:



Pierce

Manufactured by: Pierce Manufacturing, Inc.
- Custom Designed and Manufactured Exclusively For -
CITY OF SCOTTSDALE

Mo./Yr of Mfgr Aug - 2008
Job No. 20203
WO No. 8648384
GVWR 34,836 KG (76,800 LB)
Tire-Limited Max Speed 65 mph
Chassis Velocity

GAWR	TIRES	RIMS	COLD TIRE INFLATION
Front 10,342 KG (22,800 LB)	425/65R22.5 (L)	22.50x12.25	827 kPa (120 PSI) SINGLE
Rear 24,494 KG (54,000 LB)	12R22.5 (H)	22.50x8.25	827 kPa (120 PSI) DUAL

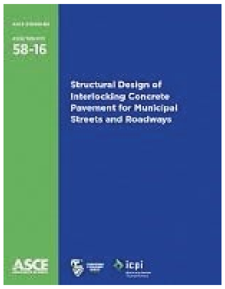
THIS VEHICLE CONFORMS TO ALL APPLICABLE U.S. FEDERAL MOTOR VEHICLE SAFETY STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE.

Ladder Engine: Pierce Manufacturing ID Decal; GVWR - 76,800 lbs.
GAWR – Front = 22,800 lbs. = 11,400 lbs./tire:
GAWR - Rear = 54,000 lbs. = 27,000 lbs./axle; 6750 lbs./tire
Cold Tire Inflation Pressure – 120 psi (single and dual)
Max Load per Single Tire – 11,400 lbs.

DESIGN ESALs

Design references have been developed by several credible organizations including AASHTO, ASCE and Caltrans as shown below. In almost all cases, the design guidelines for the structural aspects of the pavements are based on the 1993 AASHTO Guide for Design of Pavement Structures (AASHTO 1993). As with the design references for ICP and PICPs, the 1993 AASHTO document calculates the thickness of a roadway cross section required to withstand the applied loads for the given lifespan based on the native soils strength and traffic loading. The supporting soil strength is typically described by a CBR value (California Bearing Ratio), Mr (Resilient Modulus), R-value or some other geotechnical measurement describing the strength of the supporting soil. The traffic loading is typically described by TI (Traffic Index), ESALs (Equivalent Single Axle Loads) or other measurement to express the traffic type and equivalent damage (VLF, Vehicle Load Factor) created by each type of vehicle as compared to the passage of a "standard" 18,000-pound axle load (one 18,000 lb. ESAL provides a unit value of 1.0). For perspective on ESALs, passenger cars have a Vehicle Load Factor (VLF) of 0.0004 whereas a fully loaded fire truck as shown above would have a VLF of about 10. Hence, it would take over 20,000 cars to affect the same level of deterioration on the pavement as 1 pass of a fire ladder truck. It should be noted that not all fire trucks exhibit this same degradational effect on pavements as most are lighter and exhibit considerably lower axle loads than the Ladder Truck which has a GVWR (Gross Vehicle Weight Rating) of 76,800 lbs.

Although it is evident by the VLFs shown above that fire trucks can exert high ESALs on the pavement surface, it is important to note that typical roads are designed around hundreds of thousands of ESALs, so the impact of the occasional fire truck is relatively small on those pavements. Notable in the design procedure is that the axle/tire loads applied to the completed pavement system is transferred through the pavement to the subgrade via a series of structural layers which distribute the vehicle loads to a relatively large area of the subgrade. The distribution of the loads through the pavement system enables relatively weak subgrades to support very high concentrated axle/wheel loads much like a snowshoe or wide tracks of low ground pressure vehicles to traverse low strength materials which would otherwise not support the weight of applied loads. Along those same lines, pavement design isn't so much about how much a vehicle weighs but rather the load transfer of axle loads through the pavement system and how many passes can be achieved prior to development of unacceptable rutting or excessive pavement deterioration.


58-16

Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways

ASCE

icpi

To further expand on this subject, pavement sections for standard asphaltic concrete (AC) and aggregate base systems and interlocking concrete pavement (ICP) systems are essentially identical in thickness with the wearing course being the primary difference in the systems. In essence, an 80mm (3-1/8") thick paver laid on 1" of bedding sand provides a structural number of 1.82 for the pavement layer which is the same as 4-1/8" of asphaltic concrete having a layer coefficient of 0.44/inch (0.44 x 4-1/8 = 1.82). Therefore, a 101.6 mm (4") thick paver laid on 1" of bedding sand provides a structural number of 2.20 for the pavement layer, which is comparable to 5" of asphaltic concrete. The aggregate base and subbase section used to distribute the wearing course loads provide the same support to either an AC or ICP system. The above analogy can be verified by comparing section thicknesses for designs done in accordance with AASHTO (AASHTO 1993) and ICPI (ICPI 2011) or ASCE (ASCE 2016) methods.

TIRE CONTACT PRESSURES

In terms of being able to withstand the surface pressure exerted by fire truck tires, the gross axle weight rating (GAWR) on a two tire (steering) axle and tandem axle (rear axles) for the 76,800 lb. fire truck referenced above is 22,800 lbs. and 54,000 lbs., respectively. Each tire is rated at a max load rating of 11,400 lbs. at a cold inflation tire pressure of 120 psi. By definition, the maximum applied contact pressure is then 120-psi.

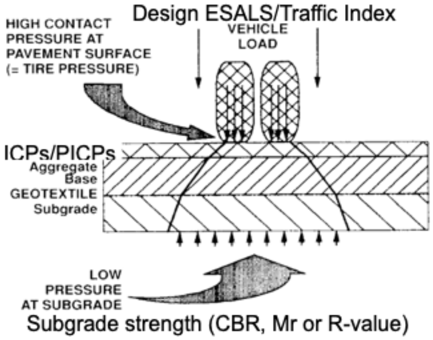
Any concrete paver offered under the Belgard line is made in accordance with ASTM C936, which requires an average compressive strength of 8,000 psi with no individual unit being less than 7,200 psi. So, simply put, the pavers are on average 8000/120 > 60 times stronger in compression than required to withstand the surface pressure that would be exerted under the extreme loading conditions imposed by a fire truck.

POINT LOADS

When the stabilizer outriggers are in place, a point load of as much as 45,000 pounds can be applied to the pavement surface. Although significant, when distributed over an "un-factored" stabilizer plate surface area of 0.97 square feet (area of 10x14 inches), this equates to a surface pressure of 322 psi, which again is well within the compressive strength capabilities of Belgard pavers.

PAVER DAMAGE

As a final thought, should one or more pavers become damaged, individual units can be removed and replaced without compromising the structural integrity of the system (instruction manual available upon request).



Structural Pavement Section function of Subgrade Strength, Traffic Loadings and Strength of Pavement Components

REFERENCES

1. *AASHTO 1993. Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, Washington, DC.*
2. *ASCE 2016. Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways, ASCE/T&DI/ICPI Standard 58-16, American Society of Civil Engineers, Reston, VA.*
3. *ASCE 2018. Permeable Interlocking Concrete Pavement, ASCE/T&DI/ICPI Standard 68-18, American Society of Civil Engineers, Reston, VA.*
4. *Caltrans 2016. Pervious Pavement Design Guidance, California Department of Transportation, Division of Design, Office of Storm Water Management, Sacramento, CA.*