# HIGH PERFORMANCE CONCRETE BARRIERS FOR WORK ZONES

## INTERNATIONAL REQUIREMENTS AND STATE OF THE ART SOLUTIONS

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**ABSTRACT**

Selecting appropriate safety barriers for construction sites on roads is essential for the safety of motorists and construction site personal. Depending on local circumstances and national regulations, the traffic manager in some countries is quiet free in his choice. Some nations provide very detailed requirements in terms of the barriers´ performance classification and their application area.

The market offers a wide range of products for temporary protection. Normally these safety barriers must be crash testes according to the European EN 1317 or the US Mash standard. In the field of precast concrete barriers you can find numerous solutions for all containment levels. Moreover, the traffic manager can select from various design types and barrier heights for the optimal safety performance at the specific application. Systems with higher containment levels should be considered on roads with increased heavy-vehicle traffic. Slim barriers are the best choice when separating contraflow traffic or when the barrier must be placed very close to the construction site.

Today modern high performance barriers fulfill all the requirement of work zone protection. Setting the right performance requirements and choosing the right system for sure is essential for both authorities and traffic managers.

## CHARACTERISTICS AND PERFORMANCE OF WORKE ZONE SAFETY BARRIERS

The original purpose of a work zone safety barrier is quiet simple. If there are road works or temporary obstacles influencing the traffic flow safety barriers are needed to guide the traffic, protect traffic users and secure the work zone. However it can be recognized that a whole new understanding of work zone protection was generated in the last two decades to realize both maximum safety for road users and workers and minimum impact on the flow of traffic. The main properties of work zone safety barriers are described in the respective standards. EN 1317 defines performance classes such as containment level, working width and acceleration severity. Following the standard each performance class provides clear parameters so that different products can be compared and characterized for their best use. On top of that the market requirements and economic pressure brought up additional product requirements a modern work zone safety barrier must fulfill today.

### Containment Level

The EN 1317 generally foresees different containment levels for crash testing barriers at different impact energies. The standard varies the impact energies by changing the vehicle type and weight, the impact angle and the impact speed. The smallest containment level results in an impact energy of 6,2 kJ whereas the highest is more than 700 times bigger at 724,6 kJ. The majority of work zone safety barriers in Europe are crash tested at containment level T3 due to the biggest market for that specification. Only in some countries like the United Kingdom high containment levels are required up to H4a.

**TABLE 1 Containment levels and impact energy according to EN 1317-1 (former version)**

| Containment level | Kinetic energy kJ | Traffic face deflection m | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0,1 | 0,4 | 0,8 | 1,2 | 1,6 | 2,0 |
| | | Average force $\overline{F}$ kN | | | | | |
| T1 | 6,2 | 16,8 | 9,3 | 5,8 | 4,2 | 3,3 | 2,7 |
| T2 | 21,5 | 36,5 | 24,2 | 16,7 | 12,7 | 10,3 | 8,6 |
| T3 | 36,6 | 46,7 | 33,8 | 24,7 | 19,4 | 16,0 | 13,6 |
| N1 | 43,3 | 59,2 | 42,0 | 30,3 | 23,7 | 19,4 | 16,5 |
| N2 | 81,9 | 112,0 | 79,4 | 57,2 | 44,7 | 36,7 | 31,1 |
| H1 | 126,6 | 93,6 | 76,6 | 61,7 | 51,6 | 44,4 | 38,9 |
| H2 | 287,5 | 133,0 | 116,8 | 100,4 | 88,1 | 78,5 | 70,8 |
| H3 | 462,1 | 266,4 | 227,1 | 189,8 | 163,0 | 142,9 | 127,1 |
| H4a | 572,0 | 311,3 | 267,6 | 225,4 | 194,7 | 171,4 | 153,1 |
| H4b | 724,6 | 269,1 | 242,1 | 213,6 | 191,1 | 172,8 | 157,8 |

### Working Width

Today the working width is setting the standards for modern work zone safety barriers. The lower the deflection at a specific impact energy the better the barrier performs. However the reduction of deflection becomes a difficult problem to solve when the barrier must be light, small and easy to install. To combine those features industry has taken huge efforts in the last years. In the last ten years state of the art in impact deflection has changed significantly. Today for example W2 is standard for containment level T3.

**TABLE 2 Working width classification according to EN 1317-2**

| Classes of normalised working width levels | Levels of normalised working width m |
|---|---|
| *W*1 | $W_N \leq 0,6$ |
| *W*2 | $W_N \leq 0,8$ |
| *W*3 | $W_N \leq 1,0$ |
| *W*4 | $W_N \leq 1,3$ |
| *W*5 | $W_N \leq 1,7$ |
| *W*6 | $W_N \leq 2,1$ |
| *W*7 | $W_N \leq 2,5$ |
| *W*8 | $W_N \leq 3,5$ |

NOTE 1 In specific cases, a class of working width level less than *W*1 may be specified.

NOTE 2 The dynamic deflection, the working width and the vehicle intrusion allow determination of the conditions for installation of each safety barrier and also to define the distances to be provided in front of obstacles to permit the system to perform satisfactorily.

NOTE 3 The deformation depends on both the type of system and the impact test characteristics.

**FIGURE 5 Working width W2 after a TB41/T3 impact (36,6kJ impact energy) on a 125kg/m slim-type barrier**

**Acceleration Severity**

To achieve a good level of acceleration severity is typically no problem for barriers tested for low impact angle containment levels such as T1 to T3. In this category almost all modern products provide ASI A according to EN 1317. However at higher containment levels the ASI is determined with another type of vehicle and a different impact angle. Therefore the ASI of a T-level barrier should never be compared with an ASI of a N2 or H-level barrier. Following todays safety levels ASI A and B are obligatory in those categories.

**TABLE 3 Acceleration severity classes according to EN 1317-2**

| Impact severity level | Index values | | |
|---|---|---|---|
| A | ASI ≤ 1,0 | | |
| B | ASI ≤ 1,4 | and | THIV ≤ 33 km/h |
| C | ASI ≤ 1,9 | | |

## Design Width of the Barrier

Maximizing the room for both the flowing traffic and the work zone is obligatory in modern traffic management. This results in the fact that only barriers with best working width performance are used in high grade infrastructure work zones. As the working width of a safety barrier is defined by its design width and deflection the trend for small barriers seems logical. However the main driver for slim safety barriers is their application as separators for contraflow traffic. Often the opposite traffic lanes are within the barriers working width for that type of application therefore the design width is the crucial aspect.

**FIGURE 5 Standard New Jersey type barriers at 500kg/m, 60cm width (l), slim type barriers at 180kg/m, 32cm width (m), superlight slim-type barriers at 125kg/m, 24 cm width (r)**

## Design Height of the Barrier

Normally a higher barrier might provide a better protection for road workers. In some countries even fences are required on top of work zone safety barriers. As the trend in developing superlight barriers might result in small design heights some national regulations already foresee minimum barrier heights.

## Weight of the Barrier

Technically the specific weight of a barrier has significant influence on the barriers deflection at an impact. Therefore barriers for high containment levels are generally made of concrete. Modern high containment barriers combine the advantage of the natural weight of concrete with innovative coupling methods, geometrical profiles and effective reinforcement design. This results in comparable small deflections and good acceleration severity at an impact energy beyond 700 kJ. However for the typical containment levels T1 to T3 the reduction of weight is more driven by economic thinking. The central European market for work zone safety barriers can be estimated to 1000km of barriers. These barriers are moved several times a year between construction sites. It is easy to understand that the reduction of weight directly transfers into a reduction of transport costs. The positive impact on the environment and carbon footprint is obvious as well.

**Installation Speed**

Any time consuming setup of a construction site results not only in additional costs but also in a weaker traffic flow. Modern work zone safety barriers can be installed very fast. Some types even designed to work without screws or bolts. This does not only save time. The simpler the installation the safer it is for the road workers. New installation concepts even try to realize the installation of barriers without a worker on the ground. However the width of operation of an installation team should be reduced to a minimum. Therefore many barrier types come with their special installation equipment for optimal installation performance.

**FIGURE 5/6/7 Installing Concrete Barriers – New Jersey type barriers with heavy equipment (l), slim-type barriers with screws (m), tight-fitting superlight barriers without any tools (r)**

**Durability**

In the last years a clear technology trend can be recognized for work zone safety barriers for medium containment levels T3 to N2. The industry is combining steel and concrete to achieve not only the best performance when crash testing. When concrete barriers got lighter and smaller it soon was clear that steel inlays and elastomer pads have to protect the barrier in rough installation conditions and have to increase the barriers durability and lifetime. Low containment barriers for level T1 are usually made of steel alone. Massive concrete barriers for the highest containment levels are usually heavily reinforced and provide the necessary structural strength directly without additional measures.

**Special Product Features**

Today a modern work zone safety barrier should not only show its performance on the data sheet. Many clever features make the traffic manager's job easier and provide additional safety beyond crash tests and standards. The visibility is often increased by reflectors. Many types and ways of application on the barriers provide different advantages. There are also solutions for smart and safe attachment of fences on the market. Some products provide special fixations for traffic signs. The new aspect often lays within the consideration a vehicle impact. Responsible barrier producers and authorities only allow tested and specially designed accessories.

**FIGURE 5 Temporary contraflow protection at level H4b/W6**

## NATIONAL REQUIREMENTS – AN OVERVIEW

It is a fact that some European countries do not provide guidelines or proper technical regulations for the right use of safety barriers for work zone protection. However there is also the opposite when national regulations describe the barriers application and product requirements in such detail that only specialized companies are able to operate properly. In terms of the barriers performance there can be recognized a trend towards T3 barriers. Whilst many national guidelines prescribe W4 for that containment level W2 can be seen as state of the art.

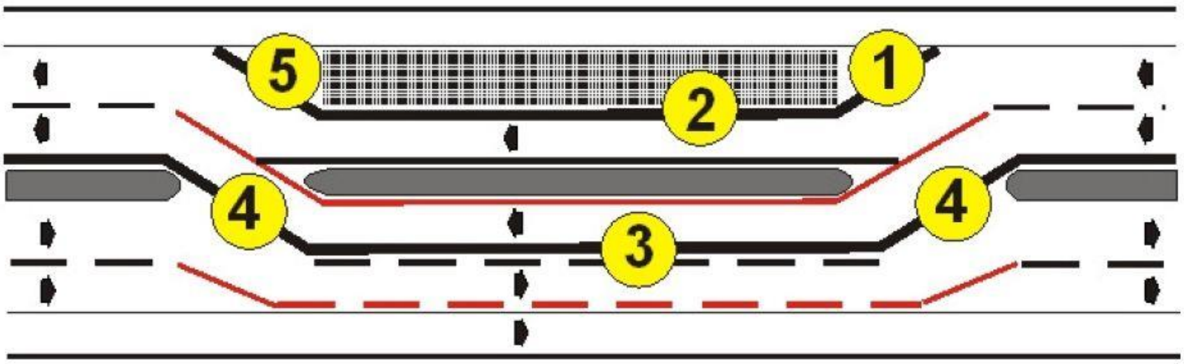


**FIGURE 5 The use of temporary barriers according tot he Austrian RVS 05.05.42 (1 H1/W8; 2 barrier use on basis of a risk assessment; 3 T3/4 or H1/W6; 4 H1/W6; 5 no barrier needed)**

In central Europe T3 is mostly used for the separation of contraflow traffic. In the approaching and exiting areas containment level H1 is widely required. As this approach makes sense for many authorities in mainland Europe the United Kingdom demands higher containment levels. For standard applications N2 is required whereas even special applications for level H4a are described. In terms of barrier performance it is interesting to see that the smallest working width at level N2 is still achieved by typical concrete barriers. They have a wider body and more weight than slim type T3 barriers but they realize W3. As N2 results in more than twice the impact energy of T3 the reduction of weight is limited when you go for smallest deflection without anchoring.

## THE RIGHT SYSTEM FOR THE RIGHT APPLICATION

The market constantly requires higher performance of safety barriers as the demand for more safety, faster installation, smaller design widths and less weight is increasing. This led the industry to develop more specialized products. One barrier type for several containment levels cannot achieve best specific performance. The typical product categories T1, T3 and N2 will bring specific barrier designs in the next view years. T1 will be typically handled by superlight steel barriers. Combining concrete and steel seems to be the right way to best way to achieve highest performance respectively smallest deflection at level T3. In future N2 will be handled by “bigger” versions of T3 barriers. When it comes down to high containment levels starting from H1 up to H4a and H4b best performance can be achieved by heavy barriers made of concrete.


**FIGURE 5 Work zone protection at level N2/W4**

## CONCLUSIONS

The regulations for safety barriers for work zones can differ quite significantly between different countries. In Europe the trend goes clearly towards containment level T3. In the meantime industry has developed many types of T3 barriers whereas the working width W2 can be seen as technical product standard. Within the classification T3/W2 it is the goal of developers to realize minimum weight, fast installation rates and easy handling without any compromise in safety. Today such barriers go down to 750kg per m and offer quick joint connections without any screws. In the field of high containment levels H4a and H4b the impact deflection has also decreased still providing acceptable impact severity for car passengers. Best overall performance is achieved when combining steel and concrete to take advantage of the materials best properties. Today simple and highly efficient connection methods work without any screws to increase installation speeds and reduce the disturbance of traffic flow.