Revista Científica del Centro Universitario de la Guardia Civil
Revista Lógos Guardia Civil

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STUDY OF PEDESTRIAN BEHAVIOUR WHEN USING ALTERNATIVE PEDESTRIAN CROSSINGS PROVIDED DUE TO CONSTRUCTION WORK OCCUPYING THE PAVEMENT IN THE PROVINCE OF CIUDAD REAL.

Choice of appropriate beacons.

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Resumen: Los atropellos y accidentes de tráfico son una de las primeras causas generadoras de traumatismos con altos porcentajes de discapacidad y muerte en el mundo. En muchas ocasiones, las zonas peatonales son invadidas por obras en el acerado y es necesario realizar un paso alternativo en la calzada, incrementando así el riesgo de atropello. En el presente artículo, se analiza el tránsito y el comportamiento de los peatones a través de pasos alternativos en la calzada en las situaciones en las cuales se desarrollan trabajos eléctricos en la vía pública que ocupan totalmente la acera. Para ello, se han considerado tres modelos de análisis: en función de la separación de las zonas de peatones y vehículos, de la densidad del tráfico rodado y de las actividades desarrolladas en la obra. Los experimentos se han realizado en distintas poblaciones de la provincia de Ciudad Real (España).

Abstract: Road hits and accidents are one of the leading causes of injuries with high percentages of disability and death in the world. On many occasions, pedestrian areas are invaded by works on the sidewalk and it is necessary to carry out an alternative passage on the road, increasing the risk of being hit. This article analyzes the transit of pedestrians through alternative steps on the road in situations in which electrical work is carried out on public roads that completely occupy the sidewalk. Three analysis models have been considered: based on the separation of pedestrian and vehicle areas, the density of road traffic and the activities carried out on the site. The experiments have been carried out in different towns in the province of Ciudad Real (Spain).

Palabras clave: accidentes peatonales, comportamiento vial planificado, movilidad peatonal, seguridad vial, obra civil urbana.

Keywords: pedestrian accidents, planned behavior, pedestrian mobility, road safety, urban civil works.

1. INTRODUCTION

Deaths resulting from pedestrian and vehicle collisions are a global problem. The World Health Organisation (WHO) published a report in 2004 describing this as a silent epidemic affecting all sectors of society[1].

In 2009, road traffic crashes and collisions caused 1.27 million deaths worldwide, the eighth leading cause of death globally[2]. In 2022, 12,629 pedestrians were involved in a road accident in Spain[3], with a total of 348 people killed[4] and 1623 hospitalised.

Road safety depends mainly on the human factor, the vehicle and the road infrastructure (Sivilevičius, 2011). A fourth element is the concept of exposure, defined as the probability of an event occurring according to the distance travelled (Pico, González and Noreña, 2011).

It is estimated that 90-95% of road accidents are solely the result of the human factor (Rumar, 1985). In order to reduce high road accident rates in Spain, lawmakers in the field of criminal law have focused on accidents resulting in death or injury caused by reckless behaviour committed with a motor vehicle or moped, characterising recklessness depending on social demand (Martin, 2024).

In terms of the study of individual behaviour relating to road safety, the psychological literature has historically been more focused on the study of driver behaviour than pedestrian behaviour (Moyano, 1999). These studies have shown that, among other actions, road safety education allows citizens to acquire traffic behaviour and pedestrian safety habits, eliminating bad risk behaviours such as crossing streets at times or places that are not allowed (Conejera, Donoso, Moyano, Peña and Saavedra, 2003).

In terms of infrastructure and its environmental setting, road safety interventions directed at drivers and pedestrians such as guardrails, traffic signs, improved street lighting, pedestrian crossings, etc., can substantially eliminate the risk of pedestrian collisions (Fruin, 1974).

In terms of traffic-related safety, another important factor is the speed limit on the road, as there is a relationship between speed and the severity of accidents. In a traffic accident, the occupants of a vehicle impacting at 80 km/h are 20 times more likely to be killed than in a 32 km/h impact (Ashton and Mackay, 1979). According to the WHO (2004), this ratio is particularly lethal for pedestrians, since in impacts at speeds of 32 km/h, 5% of pedestrians hit by vehicles die in the accident. However, at 48 km/h this figure rises to 45% while at a speed of 64 km/h the percentage of pedestrians killed rises to 85% (Montoro, Roca and Lucas-Alba, 2010).

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[1] WHO. (2004). World report on road traffic injury prevention. https://www.who.int/violence_injury_prevention/publications/road_traffic/world_report/summary_es.pdf

[2] WHO. (2009). Global status report on road safety: time for *action*. https://www.who.int/violence_injury_prevention/road_safety_status/report/web_version_es.pdf

[3] DGT. (2023). The main road accident figures for Spain 2022. http://publicacionesoficiales.boe.es/

[4] DGT. (2023). Persons killed in a collision are counted from the time of the first manoeuvre and not from the result of the injury.

Therefore, traffic speed has a major impact on how pedestrians act, as it determines their sense of safety (Sanz, 2008). This aspect determines that local administrations and entities must introduce different initiatives in the urban design of the city such as traffic-calming, speed reduction or shared space, which will have a positive impact on the pedestrian quality of streets (Prinz, 1986) (Pozueta, Lamíquiz and Porto, 2009).

For these reasons, the Road Safety Committee of the Congress of Deputies unanimously adopted an institutional declaration (Ref. 6) at its session on 12 November 2020, on the occasion of the World Day of Remembrance for Road Traffic Victims, welcoming the Government's initiative to draw up the Road Safety Strategy for 2021-2030, and urging that it respond to the principles of the Safe System (DGT, 2022).

The Road Safety Strategy 2030 aims to reduce the number of traffic crashes and casualties on public roads in Spain by promoting and coordinating the actions and results of all actors involved in the field of safe mobility, acting in a transversal and comprehensive manner on people, infrastructure and environments, vehicles and post-crash response, through legislation, training and education, surveillance, technology and better data and governance.

2021-2030 should be the decade of Insurance System consolidation, developed on the basis of the following principles:

1. Principle of fallibility: people make mistakes that can lead to accidents.

2. Principle of vulnerability: the human body has a limited capacity to tolerate the force of an impact without injury.

3. Principle of shared responsibility: there is a shared responsibility between those who design, build, manage and use roads and vehicles, as well as those who provide post-crash response.

4. Principle of holistic approach or redundancy in the face of risk: all parts of the system must be reinforced to multiply their effects, so that if one part fails, people are still protected.

One of the main areas of the Road Safety Strategy 2030 is the establishment of safe cities, developing and disseminating, in collaboration with local authorities, methodological guidelines that facilitate the integration of road safety in sustainable urban mobility plans (SUMPs) and mobility ordinances, designing cities that can guarantee universal accessibility.

However, it is not uncommon for public roads to be occupied by works for new amenities, improvement or repair of essential services (electricity, water, gas, etc.), which can alter environmental road factors with generation of noise and dust, among other unfavourable elements. At the same time, on some occasions, the work area completely encroaches on the pavement, making it necessary to create new routes for pedestrians by making alternative crossings on the road, where both vehicles and pedestrians coincide.

Therefore, it is essential to plan correctly before beginning construction, including risks associated with the creation of alternative crossings and preventive measures to protect pedestrians, as the Director General of Traffic, His Excellency Pere Navarro Olivella, pointed out at the inauguration of the Cities on Foot Forum in Madrid on 5 March 2019.

Pedestrians are the weakest link in the mobility chain and the proof of this is that more than 300 people are killed by being hit by cars every year in Spain, and these figures soar among older people, who account for more than 70% of those hit by cars. (DGT, 2019, p. 6).

This is why local administrations and entities have drafted mobility ordinances that regulate the signalling and distances of alternative crossings due to the occupation of public roads by construction works, without having unified criteria regarding marking materials[5].

For drivers, signage should be used minimally to enable the driver to anticipate and carry out any necessary manoeuvres comfortably, avoiding overloading the driver's attention with unnecessary signs.

Moreover, regarding pedestrian traffic through alternative crossings provided, pedestrians may behave differently depending on their perception of the risks. These include risks caused by modification of the environmental road factors during construction work, traffic density and the model and materials used in the delimitation of pedestrian and vehicle areas on the road. These factors may well affect the correct pedestrian traffic through the alternative crossings provided.

In this study, pedestrian traffic is analysed by means of alternative crossings on the road in situations in which different civil works are carried out on public roads that completely occupy the pavement. We compare three models of marking between the pedestrian and vehicle zones: fences, plastic chains and reflective cones, these being the materials most commonly used by companies as elements for delimiting work zones on construction sites.

2. MATERIALS AND METHODS.

2.1. SAMPLE.

The behaviour of 309 pedestrians was analysed. These were diverted from their pedestrian route onto the roadway through an alternative pedestrian crossing. This was due to the occupation of the pavement during the execution of works for the improvement or repair of the electricity supply network and covered different phases, such as the opening of conduits with civil works machinery, opening of coves with electrical and manual tools, installation of electrical lines on façades, placement and removal of wooden poles in low voltage line setbacks and replacement of pavements.

[5] As per road standard 8.3-IC (1989), marking means the use of certain elements easily perceptible by the driver, in order to highlight the presence of the limits of the works and the traffic regulations to which they give rise.

This analysis was carried out on 41 works executed in 17 municipalities in the province of Ciudad Real (Ciudad Real, Puertollano, Malagón, Carrión de Calatrava, Villarrubia de los Ojos, Alcoba de los Montes, Daimiel, Bolaños de Calatrava, Almagro, Moral de Calatrava, Valdepeñas, Herencia, Argamasilla de Alba, Cózar, Villanueva de los Infantes, Tomelloso and La Solana). This allowed the research data to be collected in different types of urban roads such as crossings, avenues, main streets and non-main streets with one-way and two-way traffic, in commercial, residential and industrial areas.

For the analysis, pedestrians are considered to be walking correctly when they walk along the entire route of the marked alternative crossing.

The analysis time for each experiment varied between 10 and 30 minutes depending on the density of road traffic, with longer analysis times used in experiments with lower traffic density. For the analysis, the density of road traffic on the section affected by the works was considered, counting the number of vehicles that circulated in the area during the time of the experiment.

Another experiment analysed the behaviour of pedestrians when confronted by pedestrian diversions at nearby pedestrian crossings.

2.2. INSTRUMENTS AND MATERIALS.

In the case of civil works, the work areas were delimited around the entire perimeter with city council-type fences (1 m high, 2 m wide) in order to prevent pedestrians from accessing the area.

In the case of electrical work carried out on the façade, the work areas have been delimited around the entire perimeter with 6 mm two-colour plastic chains suspended on 1 m high plastic supports.

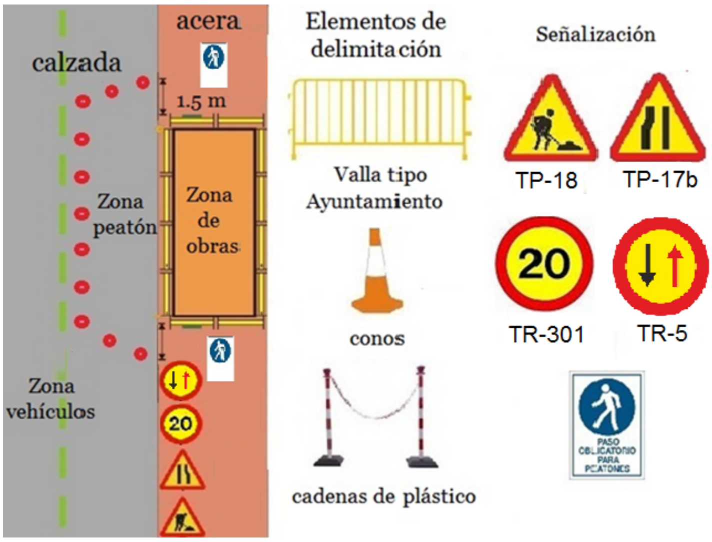
The work zones were announced with the placement of TP-18 works danger signs, TP-17, TP-17a and TP-17b narrowing of the road, TR-301 20 km/h maximum speed and TR-5 priority of opposite direction traffic in cases of two-way roads where one direction is completely invaded, as established in the Manual of examples of signage for fixed works of the Ministry of Public Works and Transport. The minimum width of the alternative pedestrian crossing was 1.50 metres provided that, on one-way streets, the width of the carriageway used for traffic was greater than 2.75 metres. The alternative crossing was announced by a pedestrian crossing sign at each entrance/exit of the alternative crossing.

The narrowing of the lane was performed by linearly decreasing its width, so that the cotangent of the angle formed by the inclined line of the narrowing of the lane with the axis of the road is not less than VL/1.6, VL (km/h) being the limited speed of vehicles at the beginning of the lane closure. By limiting the speed of vehicles to 20 km/h, the cotangent must not be less than 12.5º.

Three methods of separation were used to demarcate pedestrian and road traffic: city council-type fences, 6 mm two-colour plastic chains supported on 1 m high plastic posts and Class 2, 500 mm high, PVC reflective cones.

On two-way roads where one direction was fully occupied, traffic was regulated by signalmen.

Figura 1.
Separation method and delimiting elements used in the experiments.



3. RESULTS.

As an overall result of the 41 worksites analysed, of the 309 pedestrians who crossed the alternative crossings provided, 127 pedestrians did so correctly, and 182 pedestrians did so incorrectly (Table 1). This means that, as a percentage, 41.10% of pedestrians walked correctly and 58.90% walked incorrectly.

In the following sections, the data obtained from the different experiments were analysed according to the marking material used, the type of activity carried out and the density of vehicle traffic.

3.1. DISCUSSION OF THE RESULTS AS A FUNCTION OF MARKING MATERIAL BETWEEN PEDESTRIANS AND VEHICLES.

The first point to note from the results obtained in the experiments analysed is that of the 5 construction sites where plastic chains were used as marking material. No pedestrian passed correctly through the alternative crossing provided, which implies that plastic chains are not an advisable system as a separation element between pedestrians and vehicles.

Moreover, in the construction sites analysed where reflective cones were used as marking material between pedestrians and vehicles, of the 213 pedestrians who passed through during the experiments, 95 pedestrians did so correctly and 118 incorrectly, while in the construction sites where city council-type fences were used as marking material between pedestrians and vehicles, of the 83 pedestrians who passed by during the experiments, 32 pedestrians did so correctly and 51 incorrectly (Table 1). This means that, as a percentage, 44.6% of pedestrians passed through correctly in the case of the use of reflective cones as marking elements and 38.55% of pedestrians passed through correctly in the case of the use of fences as marking elements.

3.2. DISCUSSION OF THE RESULTS AS A FUNCTION OF ROAD TRAFFIC DENSITY.

In this section, the data has been analysed according to the density of road traffic in the area, excluding from this analysis works in which plastic chains were used as a separation element between pedestrians and vehicles, since, as we have seen in the previous section, no pedestrian passed through correctly using this method and, therefore, its use is not advisable.

For the analysis of these experiments, three sections of road traffic density were established; a first section in which the road traffic density is higher than 2 vehicles/minute (V/min), an intermediate section with a traffic density between 2 and 1 V/min and a last section with a traffic density below 1 V/min. As can be seen in table 1, in the section with the highest traffic density, 88 pedestrians travelled correctly through the alternative crossing provided and 41 pedestrians travelled incorrectly. In the intermediate traffic density section, 26 pedestrians passed through correctly and 38 pedestrians passed through incorrectly. Finally, in the section with the lowest traffic density, 13 drivers used the alternative crossing correctly and 90 drivers used it incorrectly. This means that in percentage terms, 68.22% of pedestrians passed correctly through the alternative crossing provided on the section with the highest traffic density, 40.63% of pedestrians passed through correctly on the intermediate section and only 12.62% of pedestrians passed through correctly on the section with the lowest traffic density.

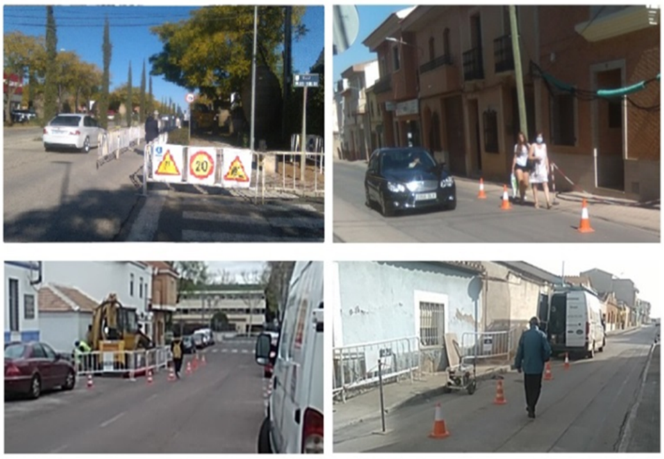
In turn, the number of construction sites where no pedestrians passed through correctly was analysed in terms of traffic density. As can be seen in table 2, of the 10 construction sites analysed where the traffic density was higher than 2 V/min, in 1 of them no pedestrians passed through correctly. In the 8 construction sites analysed where the traffic density was between 2 and 1 V/min, in 3 of them no pedestrians passed through correctly. Finally, in the 18 construction sites analysed where the traffic density was less than 1 V/min, in 12 of them no pedestrian passed correctly through the alternative crossing. This means that in percentage terms, in the section with the highest traffic density, in 10% of the works analysed, no pedestrian passed correctly through the alternative crossing, in the case of the intermediate section it amounted to 37.50% and, finally, in the section with the lowest traffic density, in 66.67% of the works analysed, no pedestrian passed through correctly.

Therefore, as shown in the experiments carried out, the density of road traffic on the road is a very important factor in the correct transit of pedestrians through the alternative crossing provided, since the higher the traffic density, the better the behaviour of pedestrians.

As an example of the above, in the upper photographs in figure 2, we can see that pedestrians are correctly passing through the alternative crossing provided on roads with high traffic density. On the contrary, in the lower photographs of figure 2, we can see the incorrect pedestrian traffic through the alternative crossing provided in areas of low traffic intensity.

Figure 2

*Examples of pedestrian traffic as a function of traffic density***.**



3.3. DISCUSSION OF THE RESULTS IN TERMS OF ON-SITE ACTIVITY.

In this section, the data was analysed according to the activity carried out on the site. Works where chains were used as a separation element between pedestrians and vehicles were excluded from this analysis, since, as analysed in section 3.1, no pedestrian passed through correctly using this marking element and, therefore, its use is not advisable.

In the construction sites analysed where there was activity during the experiment, it was observed that of the 218 pedestrians who used the alternative crossing, 79 pedestrians did so correctly and 139 incorrectly. Meanwhile, in the works where there was no activity, of the 78 pedestrians who used the alternative crossing, 48 pedestrians did so correctly and 30 incorrectly. This means that, on a percentage basis, 36.24% of pedestrians passed through correctly in the case of construction sites with activity, while 61.54% passed through correctly in the case of the use of construction sites with no activity during the experiment (Table 1).

Moreover, the number of construction sites where no pedestrians passed through correctly was analysed according to the activity (Table 2). As can be seen, of the 27 sites analysed in which there was activity during the experiment, in 16 of them,

Table 2

Summary of the results of the experiments carried out.

Type of analysis		Pedestrians passing through correctly	Pedestrians passing through incorrectly	Pedestrians passing through correctly%
General		127	182	41.10%
Separation method	**Chains**	0	13	0%
	Cones	95	118	44.60%
	Fences	32	51	38.55%
On-site activity	**Yes**	79	139	36.24%
	No	48	30	61.54%
Traffic density (D) V/min	**D > 2**	88	41	68.22%
	2 > D > 1	26	38	40.63%
	1 > D	13	90	12.62%

Table 2

Summary of the results according to construction sites where pedestrians do not circulate correctly.

Type of analysis		Works analysed	Completely incorrect circulation	
			Number	%
Separation method	**Chains**	5	5	100%
	Cones	26	12	46.15%
	Fences	10	5	50.00%
On-site activity	**Yes**	27	16	59.26%
	No	9	0	0.00%
Traffic density (D) V/min	**D > 2**	10	1	10.00%
	2 > D > 1	8	3	37.50%
	1 > D	18	12	66.67%

no pedestrians circulated correctly. Meanwhile, at the 9 construction sites analysed where there was no activity at any of them, some pedestrians walked correctly during the experiments. This means that in 59.26% of the construction sites with activity, no pedestrian was able to circulate correctly.

Therefore, as shown in the experiments carried out, whether or not there is activity on the construction site is another important factor in the correct circulation of pedestrians through the alternative crossing provided, with considerably better behaviour on construction sites where there was no activity.

3.4. DISCUSSION OF THE RESULTS COMPARING ROAD TRAFFIC DENSITY AND CONSTRUCTION SITE ACTIVITY.

As discussed in the previous sections, factors such as the activity in the working area or the traffic density in the area influence pedestrian circulation behaviour at the alternative crossings.

For the purpose of this analysis, data from the 10 construction sites where civil engineering machinery, lifting platforms or trucks were used were considered.

At construction sites where the traffic density was higher than 2 V/min, 18 pedestrians used the alternative crossing correctly and 3 pedestrians used it incorrectly, which meant that 85.71% of pedestrians used the alternative crossing correctly. Moreover, at construction sites where the traffic density was less than 2 V/min, 2 pedestrians crossed the pedestrian crossing correctly and 54 pedestrians crossed it incorrectly, which means that only 3.57% of pedestrians crossed the alternative crossing correctly.

Therefore, as shown in the experiments carried out, pedestrians' assessment of the perceived danger of being run over in areas where there is high traffic density is higher than the perceived danger due to the change in environmental factors resulting from construction activity, which implies that pedestrians used the alternative crossing correctly.

Furthermore, in cases where traffic density is not high, the perception of danger due to the change in environmental factors resulting from construction activity is higher than the perception of danger of being run over, which implies that pedestrians perceive a lower probability of being affected by a collision and walk on the carriageway instead of the alternative crossing.

An example of this can be seen in the behaviour of pedestrians in the experiment on the Ronda Eras de Malagón (Ciudad Real) (Figure 3). In the photographs above, it can be seen that the activity required civil works machinery and the demarcation material used consisted of city council-type fencing. In that day's experiment, where road traffic density was not high, no pedestrians crossed the alternative crossing, and pedestrians even waited until there were no vehicles on the road before continuing their journey outside the alternative crossing, as shown in the photographs below.

Figure 3

Experiment carried out in Ronda Eras de Malagón (Ciudad Real).

3.5. DISCUSSION OF THE RESULTS AS A FUNCTION OF THE GEOMETRY OF THE MARKING MATERIALS.

As discussed in the previous sections, factors such as the activity in the working area or the traffic density in the area influence the correct pedestrian circulation behaviour at the alternative crossings.

In these analyses, it was found that when traffic density is not very high and there is also activity on the construction site, the percentage of pedestrians who do not use the alternative crossing provided is very high.

Incorrect pedestrian traffic can lead to dangerous situations, increasing the possibility of accidents due to vehicles running over pedestrians, among other factors, because the flow of traffic on the road may fluctuate if it is regulated by traffic lights.

An example of this can be seen in the experiment carried out in Calle Capitán Fillol in Valdepeñas (Ciudad Real) (Figure 4). In this case, the stretch of road was regulated by traffic lights. As the pedestrian started to cross the alternative pedestrian crossing, the traffic light was red for vehicles and there was no road traffic, generating in the pedestrian an erroneous perception of a low probability of being hit by a vehicle, and she did not use the alternative crossing.

As the pedestrian crossed part of the work zone route, the traffic light turned green, and vehicles started to move. As a result of this situation, the pedestrian was not able to enter the alternative crossing because of the use of the city council-type fences as marking material between pedestrians and vehicles, and the vehicles had to avoid her, which could have resulted in her being run over.

Figure 4
Experiment carried out in Calle Capitán Fillol in Valdepeñas (Ciudad Real).

Therefore, it is important when planning an alternative pedestrian crossing to take into account the possibility of pedestrian misdirection by using marking elements that allow for a discontinuous distribution of markers to facilitate pedestrian re-routing and allow pedestrians to return to the alternative crossing and travel safely. At the same time, the length of these elements should be as short as possible, as the longer the route, the longer the exposure time to the hazard.

As can be seen in figure 5, in one of the experiments carried out in Barrio del Pilar in Ciudad Real, in cases where reflective cones were used as marking elements, pedestrians were able to redirect their incorrect traffic and continue their journey safely using the alternative crossing.

Figure 5
Experiment carried out in Barrio del Pilar in Ciudad Real.

It should be noted that city council-type fences have to be linked to other fences in order for the whole to be stable, and a discontinuous alignment of fences is not useful due to the high probability of them falling due to the effect of the wind.

It should also be noted that on interurban roads, pedestrian fences made of tubular elements, whether freestanding or connected, may never be used as defence devices, and, unless they are supported on flat reflective surfaces of the prescribed size, they may not be used as marking elements.

3.6. CONSIDERATIONS FOR ELECTRIC VEHICLES.

Every day, we see more and more fully electric or hybrid vehicles on our streets. According to various sources, it is estimated that by 2030, the majority of vehicle sales will be electric (Frías and Román, 2019).

The lack of noise from electric cars is another important factor to consider, as it poses an added danger of pedestrian collisions due to the lack of auditory perception of electric cars. The high weight of electric cars, over 2,000 kg in most cases, also increases the severity of pedestrian injuries. Not forgetting that electric vehicles have power ratings of over 400 hp, which makes driving these vehicles more complex, as they undergo a sharper acceleration than expected (Mérida, 2024). The insurance company AXA claims that electric cars are involved in a higher number of accidents, 50% more than conventional cars, to be precise. (Franco, 2022).

Another type of electric vehicles that are increasingly used in cities are Personal Mobility Vehicles (PMVs)[6]. PMVs, especially electric scooters, are increasingly in demand on urban roads because of their undoubted advantages in terms of cost, environmental friendliness and agility of manoeuvre, which, together with the fact that they do not require a driving licence or insurance to be able to circulate in our cities, makes them enormously attractive. However, the lack of training, the carelessness of many of their users, the absence of engine noise, as well as the absence of homogeneous regulations at the state level, have made them a considerable road safety and social problem that must be resolved as soon as possible. In 2018, according to data from the Road Safety Prosecutor's Office, there were 273 accidents involving PMVs in which 5 fatalities were recorded, (López, 2019) data that, unfortunately, are growing.

Therefore, drivers of electric vehicles must improve their perception of risk, perceiving alternative crossings as dangerous areas. This is because pedestrians, not perceiving the noise of the engine, may cultivate a false sense of security that causes them not to travel correctly through the alternative crossing and invade the roadway, which could lead to being run over.

3.7. PEDESTRIAN DISTRACTIONS.

Some pedestrians admit that they are completely distracted when crossing the street, often not looking to see if cars are coming or if the traffic light is green. These are the so-called technological pedestrians. They are not aware that, with this attitude, the risk of suffering or causing an accident increase (DGT, 2017).

In an experiment carried out in Calle Ruiz Morote in Ciudad Real due to road works that occupied the entire pavement, a detour of the pedestrian route was made along the nearest pedestrian crossings on the roadway. Due to the narrowness of the roadway, an alternative crossing could not be made for pedestrians. To warn pedestrians of the

[6] According to DGT (2022), a PMV is defined as a vehicle with one or more wheels, with a single seating position and powered exclusively by electric motors that can provide the vehicle with a maximum design speed of between 6 and 25 km/h. They can only be equipped with a seat or saddle if they are equipped with a self-balancing system.

detour, a vertical no crossing sign and a pedestrian directional sign were placed on both sides of the road in the area near the pedestrian crossings. A city council-type fence was also installed as a boundary element. Drivers were warned of the area where the works were being carried out by means of signs warning of danger of works TP-18, narrowing of the road TP-17 and 20 km/h maximum speed TR-301 (Figure 6).

The results of the experiment were that 23 pedestrians ignored the warning signs and walked through the area affected by the construction work, having to cross the road in the middle of the street as shown in figure 6.

Figure 6

*Experiment carried out in Ruiz Morote Street in Ciudad Real***.**

Several of the pedestrians who ignored the warning signs were also observed to be using their mobile phones.

The use of mobile phones reduces our ability to concentrate and perceive the risks around us, which can lead to absent-mindedness and exponentially increase the likelihood of having an accident. According to Fundación MAPFRE, the use of headphones or mobile phones increases the risk of pedestrian collisions by up to 40%. In turn, 98% of accidents involving pedestrians are caused by the use of mobile phones (DGT, 2015).

It should be recalled that the DGT establishes certain basic rules for pedestrians when walking on public roads (DGT, 2014):

a) Pedestrians should always walk along the centre of the pavements, neither too close to the edge of the road, to avoid being hit by a vehicle, nor too close to houses, in case of garage entrances or exits.

b) They should not walk on the curb and should never encroach on the carriageway, except to cross it.

c) If the street on which you are walking has no pavement or if there is an obstacle, and it is absolutely necessary to walk along that stretch, you should walk as close as possible to the wall and, if possible, facing the traffic, so that you can see approaching vehicles in front of you.

d) Young children should always walk hand in hand with adults, making sure that they play or ride tricycles or bicycles in places that are closed to traffic and never on the road. Adults should take special care when children play with balls, as these can be thrown into the road, and the natural tendency of children to run after them makes this situation very dangerous.

e) Animals should be kept on a leash, as they may escape and create a dangerous situation for other road users.

f) Pedestrians should walk in places reserved for pedestrians and not in prohibited places, e.g. in pedestrian zones and not on motorways and dual carriageways.

g) When you intend to cross a road, the first thing to consider is where you are going to cross. The safest place must be chosen, and the safest place is clearly a crossing regulated by road markings, traffic lights or traffic wardens.

h) If there is no crossing point, cross at the place where you have the best visibility, i.e. at corners, and try to avoid crossing between parked vehicles. Once you have chosen the right place, you should always stop next to the curb but without stepping on it, to avoid being hit or run over by vehicles driving close to the curb. First look to the left, then to the right and finally to the left again. After checking that no vehicle is coming, cross in a straight line as fast as possible, but do not run.

i) If a vehicle appears unexpectedly during the crossing, it is best to stop without hesitation, if possible, in the centre of the road, and wait for it to pass.

4. ACKNOWLEDGEMENTS.

We would like to thank the companies Naturgy, Applus Norcontrol, Tecmoelectric and Electricidad Jesús Bárcenas, S.L. for their willingness and commitment in carrying out these field experiments.

5. CONCLUSIONS AND PROPOSALS

On a daily basis, the public highway is often blocked due to works for new amenities, improvement or repair of essential services (electricity, water, gas, etc.), thus altering the environmental factors of the road. On some occasions, the work area also completely encroaches on the pavement, making it necessary to create new routes for pedestrians by making alternative crossings on the road, where both vehicles and pedestrians coincide.

In order to avoid being run over, it is essential in terms of occupational risk prevention to carry out correct work planning that includes the risks generated for third parties in terms of road safety, in order to adopt the appropriate preventive measures with the use of adequate signalling and marking elements. It is therefore necessary for the staff performing the functions of planning and implementing preventive measures related to road safety to be properly trained and qualified.

With regard to the signposting of the construction site, it must give drivers sufficient warning of the construction site to enable them to manoeuvre smoothly. In any case, it is necessary to establish a speed limit on the road so that in the event of a collision due to driver or pedestrian negligence, the damage caused is the least harmful.

In order to define the marking material to be used for the alternative crossing when executing civil works in cases where the entire pavement is occupied, the principle of fallibility must be considered, which states that people can make mistakes that can lead to accidents. Therefore, it is important to predict the behaviour of pedestrians in relation to the various factors that may influence their correct passage through the alternative crossing.

In the analysis of the experiments carried out, it has been found that the density of road traffic and the activity taking place in the work area are two important factors influencing the correct pedestrian traffic flow at the alternative pedestrian crossings created in the roadway when the works occupy the entire pavement.

In the case of road traffic density, it has been shown that the higher the traffic density, the better the pedestrian traffic flow through the alternative crossing provided.

With regard to the activity on the construction site, it has been found that the correct transit of pedestrians through the alternative crossing at construction sites without activity is higher than at construction sites with activity.

In turn, where civil engineering machinery was used, and traffic density was not high, pedestrian misuse of the alternative crossing provided was extremely high. For this reason, it was determined that it is very important that the alignment of the marking elements be discontinuous and allow pedestrians, in cases where they are walking on the roadway incorrectly, to redirect their incorrect traffic and walk along the alternative crossing safely.

Of the three models of delimitation analysed between the road traffic area and pedestrians (plastic chains, city council-type fencing and reflective cones), it was determined that the best signalling elements are reflective cones, as they are already familiar to people as road delimitation elements that comply with the provisions of Road Regulation 8.3-IC (1989), due to the fact that they are easily seen by the driver, with the aim of highlighting the presence of the limits of the works and the traffic regulations to which they give rise. Moreover, it has been shown that the percentage of correct pedestrian traffic using the alternative crossing was better than the other two models and, in turn, its use allows pedestrians, in cases where they walk incorrectly on the roadway, to redirect their incorrect traffic and make the route through the alternative crossing safely.

After analysing the results of the various parameters considered in this work, a set of measures is proposed relating to the alternative crossings provided in the roadway due to the occupation of the pavement, both at the national and local levels, the implementation of which could lead to significant improvements in road safety:

a) Within the framework of the Safe Cities area of the 2030 Road Safety Strategic Lines, develop and improve national and local legislation on signposting, marking, defence and cleaning of works within towns, unifying criteria so that all the figures involved in the development of civil works, starting with the local administration in the granting of the works' licence, and followed by the promoter, contractor, project management, occupational risk prevention technicians, preventive resources and workers, adopt the same preventive measures in the work environment in terms of road safety anywhere in Spain.

b) The implementation of specific and periodical compulsory courses on road safety for all those involved in the development of civil works, considering this group as a transcendental group within the framework of the Road Safety 2030 Strategic Lines in terms of road education. Along these lines, all professionals in the sector will be duly trained and qualified to identify the risks derived from their work in terms of road safety and to adopt preventive measures to eliminate or reduce these risks.
c) Reinforce within the primary and/or secondary education system, compulsory seminars on good practice in road safety, including the consequences of misuse of mobile phones and headphones while walking in town, as proper road safety education and awareness is vital for society. One of the goals set out in the Road Safety Strategy 2030 is to ensure a minimum level of road safety education for all groups.
d) In the annual calendar of traffic campaigns published by the DGT, include specific campaigns to raise awareness of the increased likelihood of being run over in areas close to civil works, with due dissemination and communication throughout the media.

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