Design and monitoring of a safe pedestrian crossing facility: via Venezia Giulia, Rome

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SYNOPSIS

Nearly all the travels have their "on foot" part; walking is therefore part of the everyday life of everyone and must regarded as the most important mean of transport. Nearly all the "on foot" movements are "interrupted" by crossings of car streets; crossing points are by far the most dangerous and uncomfortable spots for pedestrians and are therefore the crucial points of a well designed and functional pedestrian networks. The design of good pedestrian facilities should be made according to pedestrians' needs, it should enhance actual and perceived safety levels.

Pedestrians' accidents are fortunately relatively rare events, the location of intervention priority only on the base of statistical data is therefore not a satisfying approach, rather more or less analytical "preventive" method, suitable to evaluate the functional level of crossing facilities, should be used. Evaluation methods should be based on simple and easy to be made measures, and should return objective and easy to be read results. The method used in the via Venezia Giulia case study is focused on the characterization of vehicular flow and of the "functional quality" of the crossing facility, which is based on quantification of pedestrians behaviour and pedestrians/car drivers interaction; moreover short interviews with users have been made to understand reactions to the novelty.

The designed crossing point is located in a peripheral zone of Rome and connect a school to a park; the crossed street has one lane/direction, a rather wide section and is characterized by high vehicular speeds. The adopted solution is characterized by the provision of a median refuge, to divide the crossing distance into two parts so to allow pedestrians to interact with just one vehicular flow at time; the provision of the island results in a change of alignment for cars that induce drivers to slow down. Observations have been made before and right after the intervention and shows good results; observations made more than one year after the construction of the facilities have been used to evaluate long term effects.

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INTRODUCTION

Nearly all the “on foot” movements are “interrupted” by crossings of car streets; crossing points are by far the most dangerous and uncomfortable spots for pedestrians and are therefore the crucial points of well designed and functional pedestrian networks. The design of good pedestrian facilities should be made according to pedestrians’ needs, it should enhance actual and perceived safety levels. A rather large literature (i.e. [1], [4], [5], [9], [11]) on this topic exists, it is nevertheless worth to verify results and performance (considering also peculiar local conditions).

SITE DESCRIPTION

“Via Venezia Giulia” is an urban road with single carriageway and one lane for direction, total width of the car reserved space is 11 m (rather wide). The street links two districts in the south-east part of Rome, and even if there is another roads that collects the majority of the demand, flows and speeds are rather high (by far higher than the existing 30 km/h limit). Moreover traffic flow is very heterogeneous, and comprehends cars as well as lorries and buses. On one side of the road there is a park (villa Gordiani) where a school and other social activities are located, the other side is characterized by private houses, and several small commercial, social and cultural activities.

ANALISYS METHODOLOGY

Results of European as well as Italian research project on pedestrian mobility, carried on during the last years (among the other PROMPT, new means to PROMote Pedestrian mobility in cities, FP5 European Commission) show that road accidents with pedestrians involved are relatively rare. Statistical data, regarding pedestrian accidents distributions and trends, are therefore usually scattered and statistically unreliable. Moreover a dangerous spot can be characterized by a very low number of accidents just because pedestrians (or some pedestrian categories) do not use the crossing point, use it experiencing a low quality level (i.e. long waiting times, high perceived dangerousness) or look for a safer alternative. The proposed approach do not consider accidents as the only significant events that contribute in depicting the performance level of an infrastructure, but try to “measure” the actual safety level, and the overall performance looking at users’ behaviour as the most important factor in its definition. An original process have been developed and used, it took inspiration from the Swedish Traffic Conflict Technique [6] and is mainly based on quantitative observations of traffic flow characteristics and crossing pedestrians rather than subjective evaluations of expert teams (i.e. Safety Audit [8]). The idea is that a safe crossing point requires a good interaction between drivers and pedestrians, the quality of this interaction is therefore monitored and evaluated according to a combination of different parameters which are related to three main aspects: pedestrians, vehicles and street geometry.
For each aspect the following parameters have been selected.

Pedestrians

The evaluation of the interaction quality, and therefore the overall crossing quality can be made taking into account:
Crossing manoeuvres completed without interaction between drivers and pedestrians: pedestrians have crossed the street without influencing the behaviour of any car drivers. This is obviously a good condition but is only dependent on the superposition of car flow and crossing demand, therefore does not give any indication about the quality of the infrastructure.
Crossing manoeuvres completed with interaction. Car drivers and/or pedestrians have naturally adjusted their behaviour to allow crossing manoeuvres safely coming to a end. A large amount of “completed with

interaction” manoeuvres usually indicate a well designed crossing point: good visibility, short distances and low speeds allow pedestrians to easily and smoothly take their right of way.
Crossing manoeuvres uncompleted with interaction. Users have adjusted their behaviour safely, but pedestrians have not taken the right of way, and the crossing manoeuvre is therefore “uncompleted”. A majority of this situation may indicate a safe but somehow defective crossing facility: visibility allow a good interaction level, but for instance high speeds, long crossing distances prevent pedestrians from taking their right of way.
Number of cars a pedestrian give way before crossing: this gives a rough idea of the perceived waiting time at crossing point; possible reason of long waiting times may be high car speeds in conjunction with high flow rates, bad visibility of waiting pedestrians (for instance because of parked cars), long crossing distance.
Crossing manoeuvres completed/uncompleted with conflict. A conflict occurs when users are on a collision course and if no one adjust their behaviour a collision occurs: a car driver brake sharply, a pedestrian steps back or springs ahead. This easily indicates bad safety and quality conditions, a lack of visibility doesn’t allow a safe interaction, and very high car speed together with long crossing distances do not allow pedestrian to right evaluate the situation (time needed to cross, available time to complete the crossing manoeuvre, and so on).

Vehicles

Where “measuring” pedestrians behaviour need more or less innovative approaches, classical parameters, normally used to characterize traffic flows can be effectively used to describe vehicular flow characteristics, once again the quality level is not directly related to them, even if observation shows that a strong relationship exists. Vehicles related parameters can be divided in two groups, the first is related with qualitative aspects (mainly related to speed), the latter with quantitative aspects (flow rate); it is important to underline that normally parameters belonging to the second category can only slightly affected by changing in crossing point design.
The *85th percentile* (speed which is not exceeded by 85% of the passing cars), gives a rough idea of the traffic characteristics in term of speed, and can be used as a representative value.
The *statistical dispersion* of speeds (for instance standard deviation or frequency chart), gives indication about uniformity of speeds. With steady speed characteristics (low standard deviation) the interaction between drivers and pedestrians is easier, and allow pedestrians to better evaluate the time of arrival of the approaching vehicles. Low standard deviations are easily connected with the road design, and may be used as an indicator of its quality.
The maximum speed, is the highest speed recorded during the observation time, it is not particularly meaningful but can be used to have an idea of the speed allowed by the infrastructure (without the conditioning of other users, traffic rules and so on). Streets with a particularly high maximum speed are probably too wide or too straight and are easily suitable for a reshaping.
The *flow rate* (for instance vehicle/h) is important to give the idea of the importance of the street. High flow may be negative for pedestrians, but, on the other hand, very low flows are often associated with high speed, and/or may induce pedestrians to lower their level of attention, leading to unsafe conditions.
The *Gaps distribution* (by time) between passing vehicles should be recorded and statistically analysed. Gaps are dependant on speed and flow rate, small values are always negative for the quality of the crossing point, in particular if associated with high speed.
The *Vehicles type* (rate of different type of vehicles), is important according two different point of view: on one hand it have been demonstrated that pedestrians do not like to interact with huge vehicle, and tend to refuse to cross the street in front of a bus or a truck, on the other hand the presence of big vehicles has to be taken into account during the design stage, for many solution are not compatible with this kind of traffic flow.
Roughly two categories can be considered: light (cars and small van) and heavy vehicle (trucks, buses etc.).

Street Geometry

The quality of the crossing point is not directly evaluated through physical parameters, nevertheless they are important to develop possible improvements of the actual situation.
The main physical characteristics of the road have to be recorded (width of the carriageway, number and width of the lanes, width of pedestrians sidewalks, alignment, notable visual obstacles, etc.). the result of this survey is normally a sketch of monitored stretch of road.

MONITORING OF THE CROSSING POINT “BEFORE” THE INTERVENTION

Geometrical Characteristics

In order to have a more organic view of the spot measures have been made in three different points (see picture), results show that differences are small. Transversal section was constant along the considered stretch of road and showed two lanes (one for direction) 3.50m width each, parking along the street on both sides (2.00m on each side) and two 4.50m sidewalks. Speed limit, before the intervention, was fixed in 30 km/h. The pedestrians crossing, located in front of the school, was marked with simple zebra stripes, without any other enforcing measure.

Vehicular Flow Characteristics

Measures have been done during an ordinary work day, away from any congestion. Vehicular speeds have been measured using a digital camcorder and processing the images with a personal computer, the camera have been hided from the view of drivers to avoid possible influence on their behaviour. Results reported in table 1 show that speeds are by far higher then the 30km/h limit. Standard deviations and frequency charts (figure 1) indicate that data are scattered, this indicate that the street design allow drivers to freely chose their speed without conditioning their behaviour.

Table 1: Vehicular speeds “before”

	Station 1		Station 2		Station 3	
	Dir. 1	Dir. 2	Dir. 1	Dir. 2	Dir. 1	Dir. 2
V_m (km/h)	43.8	40.5	44.7	42.7	38.0	38.9
St. Dev. (km/h)	7.50	8.74	8.17	7.88	7.87	7.88
V_{85} perc. (km/h)	50	49	52	50	46	57
V_{max} (km/h)	64	67	78	64	71	82
Q (veic./h)	426	396	404	396	345	225

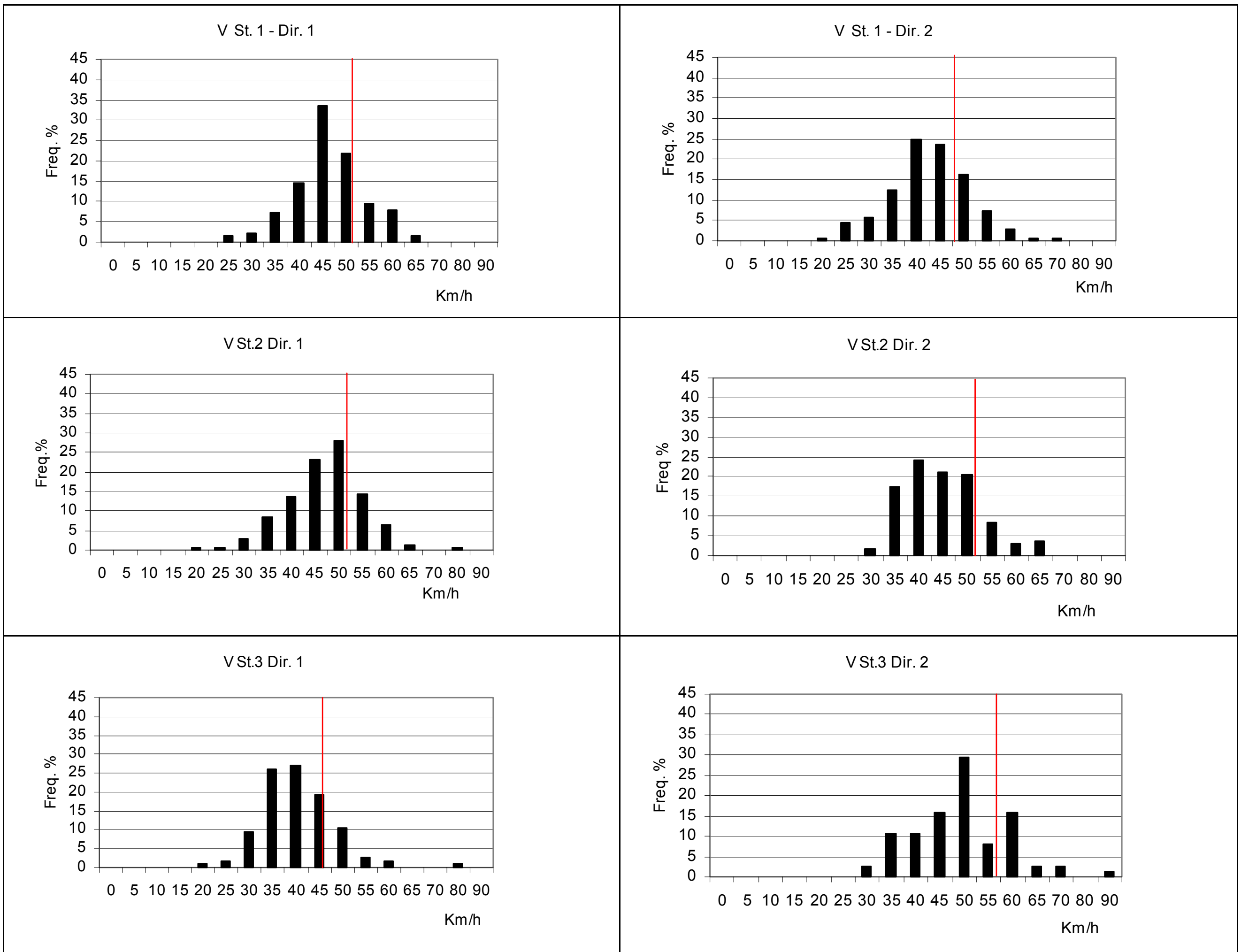

Figure 1: Speeds Frequency Charts “Before” (Red lines indicate the 85th percentile)

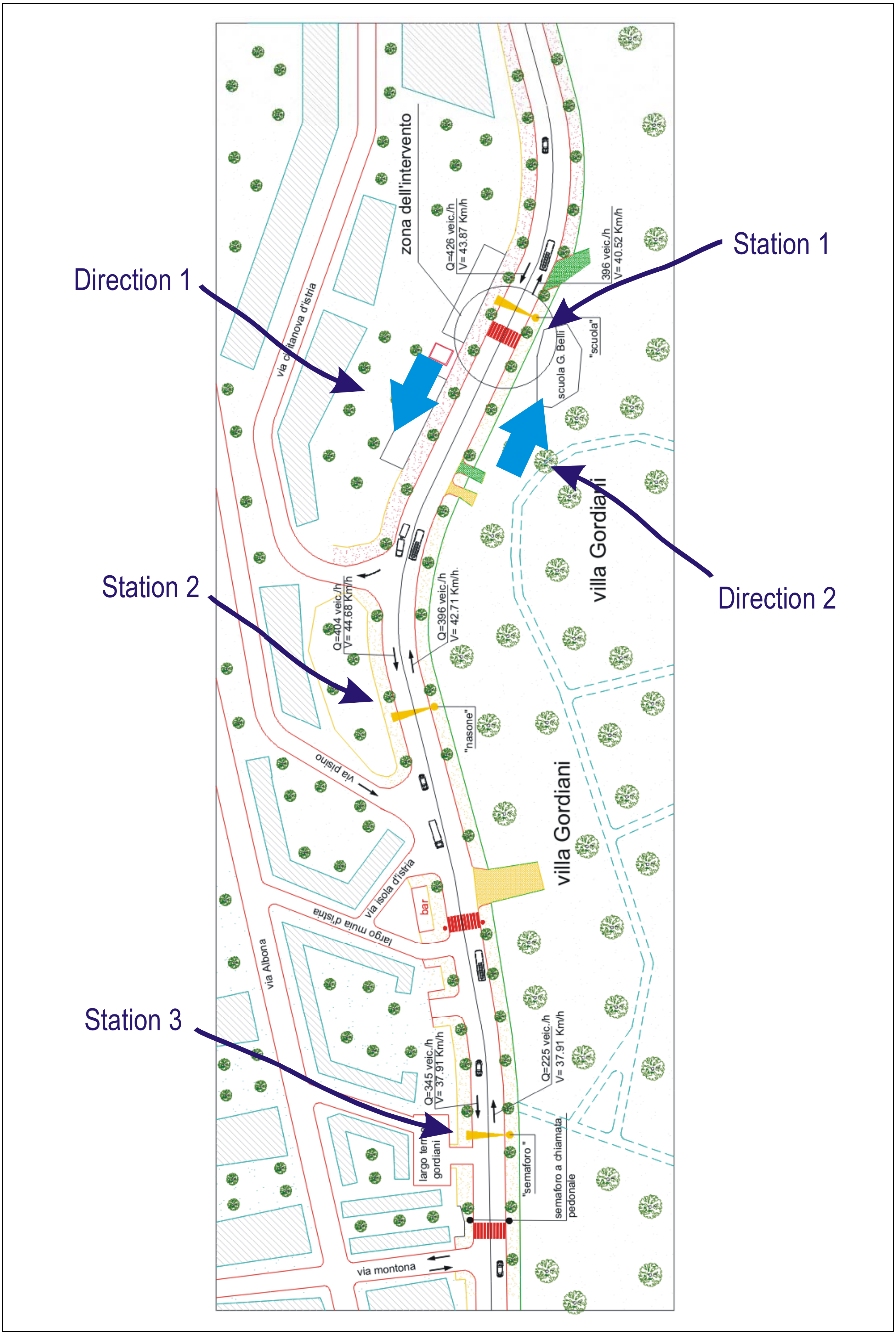

Figure 2: Via Venezia Giulia plan with measuring spots

Figure 3: The crossing point (station 1) before the renewal

Functional quality of the pedestrian crossing

Quantitative observations of crossing pedestrians have been done at the crossing point in front of the school results, as reported in table 2, show that rather small, but not irrelevant, amount of conflicts, this is a consequence of the visibility condition that are rather good; on the other side the percentage of uncompleted crossing manoeuvre is very high, pedestrians decide not to take their right of way in nearly 60% of total crossing attempts.

Table 2: Functional quality of the crossing point

Condition	Perc.
No interaction	23%
Uncompleted with interaction	58%
Completed with interaction	13%
Conflicts	6%

In order to make data easier to be read the no interaction situation (which doesn't depend on the infrastructure characteristics, rather on the distribution of gaps) can be taken away (table 3), resulting percentages show even clearer the poor performance level of the existing crossing facility. Reasons seem to be the number (2) and width (3.50m) of the lanes in connection with rather high speeds.

Table 3: Functional quality of the crossing point (only manoeuvres with interaction)

Condition	Perc.
Uncompleted with interaction	76%
Completed with interaction	16%
Conflicts	8%

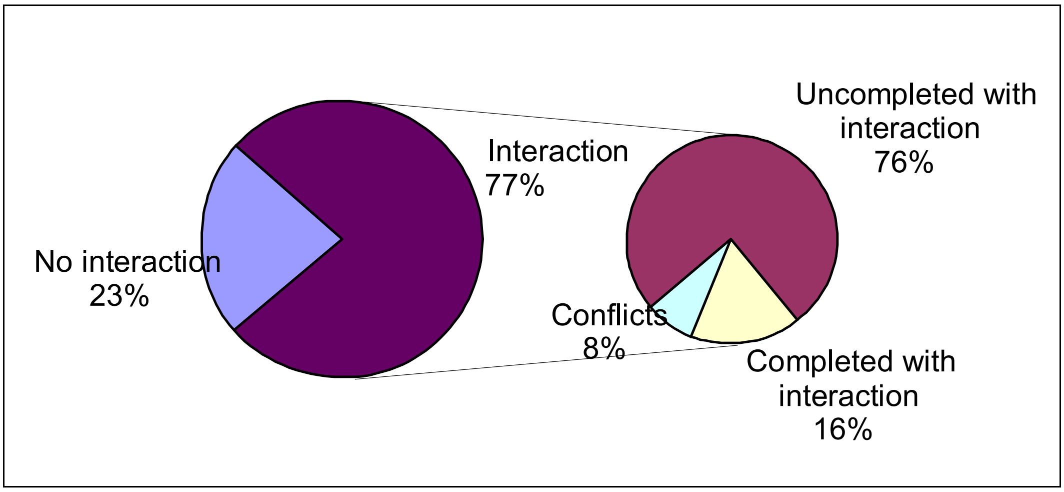

Figure 4: Functional quality of the crossing point chart

Design and realization of the new crossing facility

Analysis shows that the quality of the infrastructure is badly influenced by high vehicular speed and long crossing distance, therefore adjustments try to respond to these problems. The proposed solution (Fig. 5) is constituted by a rather large median refuge that results also in a change of alignment. The design has been made according to the Swiss Norms (SVV 640 284) about traffic calming and the Italian C.N.R B.U. n° 60 26/4/78 e C.N.R. B.U. n° 90 15/4/83.

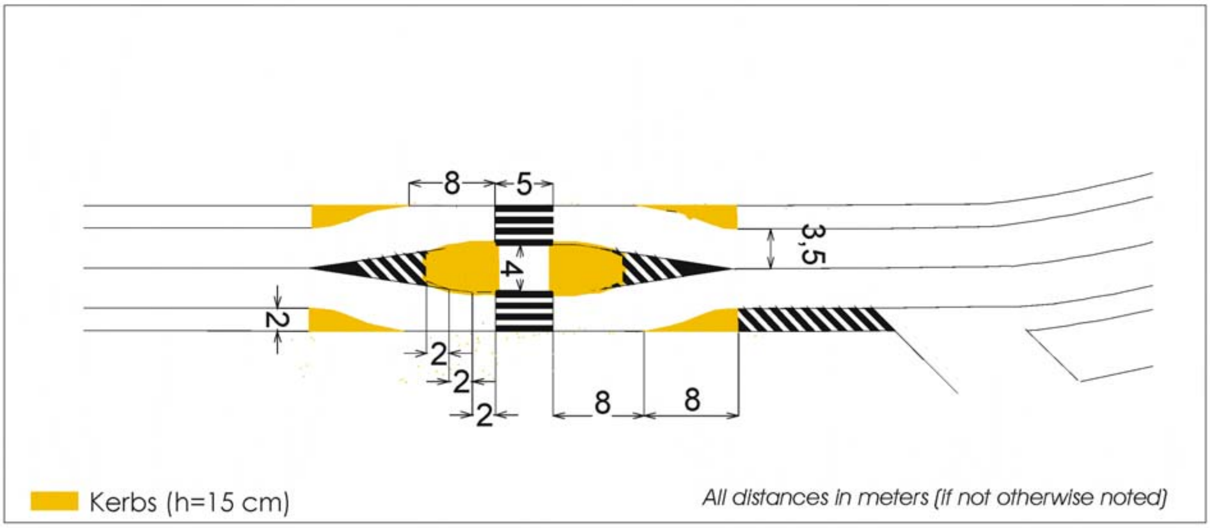

Figure 5: Design proposal

Traffic calming devices should always be inserted in coherent systems, sudden change of conditions (width, alignment, etc.). may be badly perceived by drivers and led to more or less dangerous situation [9]. In this case steering radius needed to drive through the redesigned crossing point have been considered to estimate the safety speed that resulted in 60 km/h. The computed design speed seemed acceptable; nevertheless to avoid possible problems and complain and because of the impossibility of an organic redesign of the whole stretch of road, town council technical office decided to slightly smooth the design building an infrastructure that may potentially be used at higher speed (70 km/h).

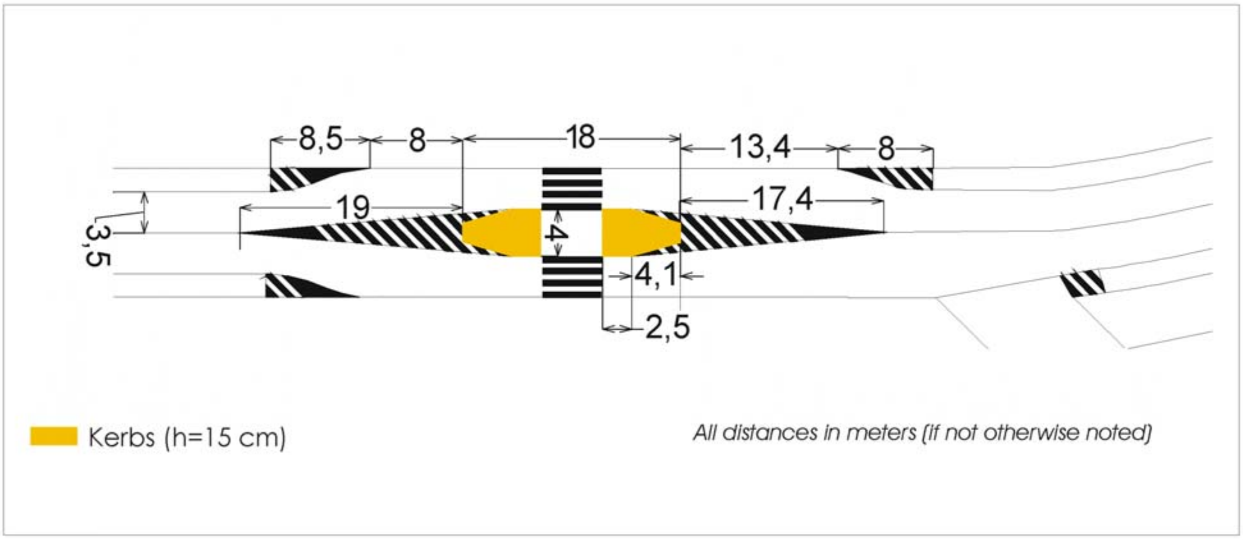

Figure 6: Final Solutions

Figure 7: Views of the new crossing point

Figure 8: View of the new crossing point

MONITORING OF THE CROSSING POINT "AFTER" THE INTERVENTION

Vehicular Flow Characteristics

Observation after the intervention show an improvement of the conditions in terms of reduction of vehicular speed. Speeds have been recorded for the two direction just before the crossing point, data show an overall decreasing of the aggregated parameters (V_m ad V_{85}) as a consequence of the change of alignment. It is on the other hand notable that no differences are exhibited by V_{max} and standard deviation, this indicate that drivers are not obliged to a defined speed, but chosen speed is still highly dependant on drivers attitude and skill. After the normality of speed distributions has been verified with a Shapiro-Wilk test, a Student's t test have been used to warrant the significance of the mean differences; these resulted in t=9.88 with degree of freedom 255 for direction 1, and t=11.5 with dof 328, thus in both cases the probability of obtaining the showed results assuming the null hypothesis (by chance) is less than 0.001. Actual vehicular speeds are generally well below the design speed computed considering possible steering radius and grip issues, also because of this standard deviation is not affected by the intervention, nevertheless average speed is notably lowered, all together these considerations indicate that the effect is more psychological and optical rather than physical.

Table 4: Comparison of vehicular Speeds "before" and "after"

Before				
	V_m	**V_{85}**	**St. Dev.**	**V_{max}**
Dir. 1	43.9	50	7.52	64
Dir. 2	40.5	49	8.73	67
After				
	V_m	**V_{85}**	**St. Dev.**	**V_{max}**
Dir. 1	34.3	42	7.87	68
Dir. 2	33.3	41	7.88	54
Comparison ("after"-"before")				
	ΔV_m	**ΔV_{85}**	**ΔSt. Dev.**	**ΔV_{max}**
Dir. 1	-9.6 (-28%)	-8 (-20%)	0.37	4
Dir. 2	-7.2 (-22%)	-8 (-21%)	-0.82	-13

All speeds in Km/h

In figures 9 an 10 speed distributions before and after the intervention are graphically shown, another view of the same data is reported in picture 11 and 12 (cumulate graphs), all representation clearly show that the standard deviation doesn't change (the width of the bell and the steepness of the cumulated chart remain the same before and after), but the overall speed decreases.

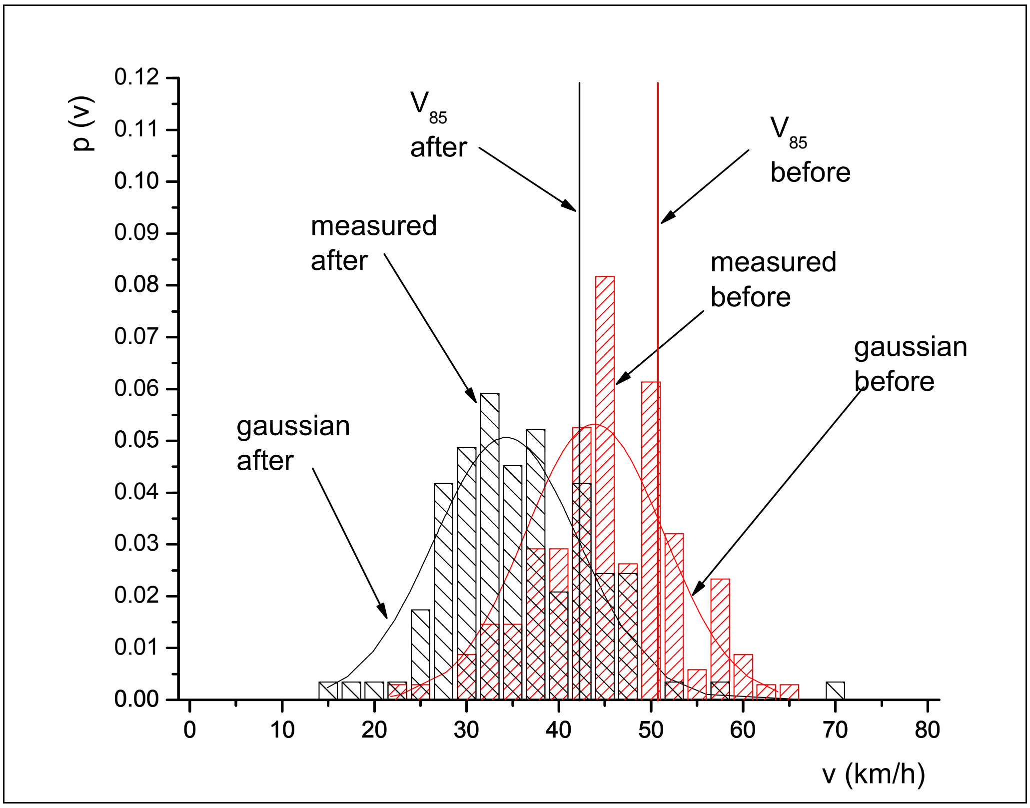

Figure 9: Speed comparison direction 1

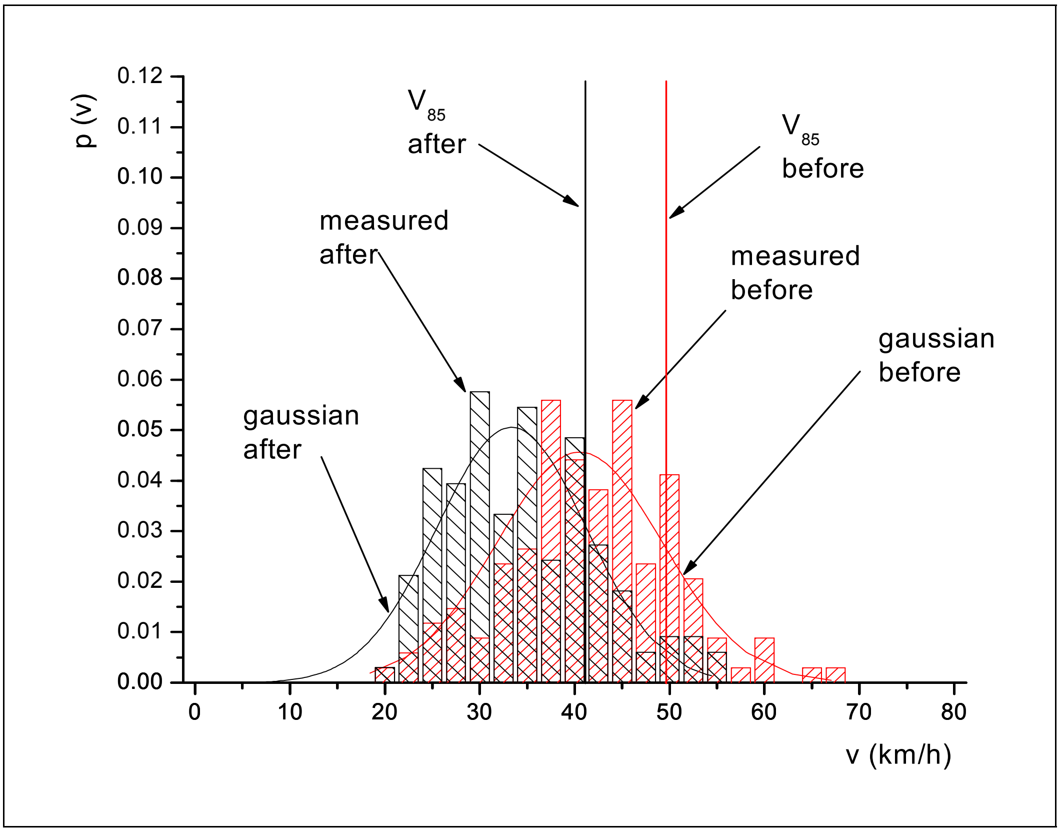

Figure 10: Speed comparison direction 2

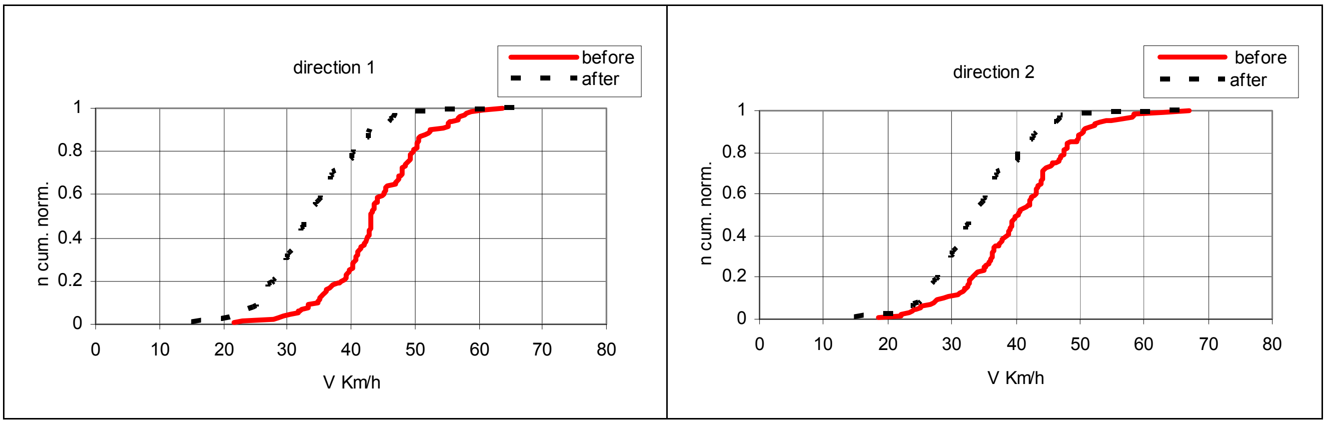

Figure 11: Speed comparison "cumulated" graphs

Functional quality of the pedestrian crossing

The new facility has a very strong effect on the functional quality of the crossing point, reasons are mainly the lower vehicular speeds and the division of the crossing distance in two parts, both factors allow pedestrians a better priority negotiation with car drivers that more often give way. Data are reported for the two crossing steps as well as aggregated, comparison with the situation before have been made only considering the aggregated data and not considering the "no interaction" case. Step 1 refers to the first part of the crossing manoeuvre (from the sidewalk to the median island), step 2 refers to the second part (from the island to the final sidewalk) regardless of the direction. The chi square test for a 2 degree of freedom problem (excluding the no interaction case) have been used to verify the significance of the shown percentage differences, and resulted in a value of 24.16 that warrants a good relationship between the variables. It is interesting that the conflicts recorded are all referred to the second part of the manoeuvre, probably because pedestrians waiting on the median platform, seeing the final goal so close, are more inclined to risk to take their right of way (but the figures are rather small).

Table 5: Functional quality of the crossing point

Condition	Step 1	Step 2	Total
No interaction	38%	35%	37%
Uncompleted with interaction	22%	17%	19%
Completed with interaction	40%	44%	42%
Conflicts	0%	4%	2%

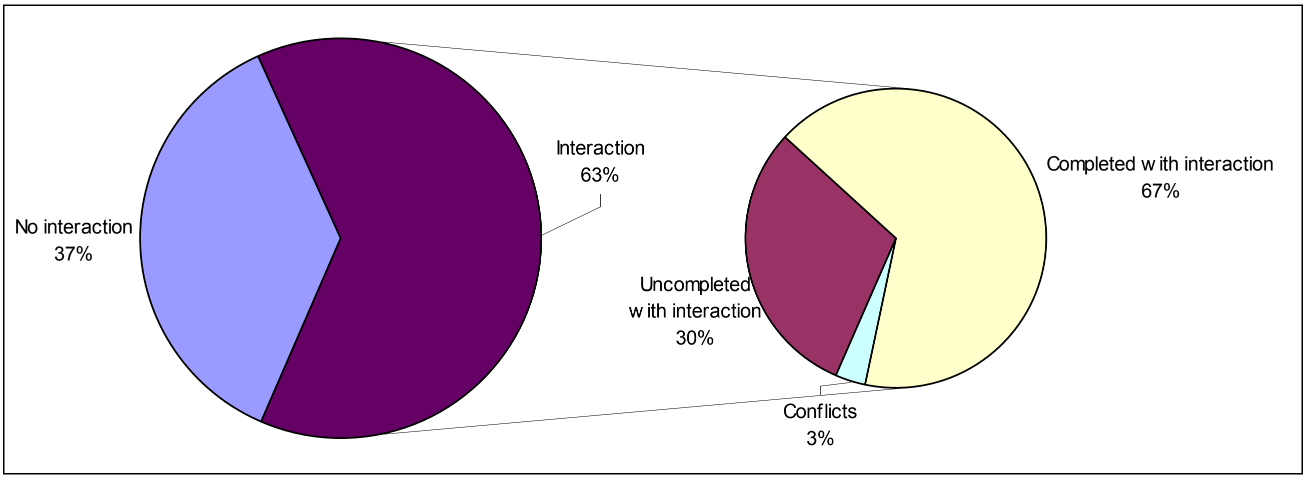

Figure 12: Functional quality of the crossing point chart

Table 6: Comparison of the functional quality of the crossing point

Condition	Before	After
Uncompleted with interaction	76%	30%
Completed with interaction	16%	67%
Conflicts	8%	3%

MONITORING OF THE CROSSING POINT 1 YEAR AFTER THE CONSTRUCTION

As one of the main complain to traffic calming devices is the stability of their performance against time, functional quality of the crossing point has been checked again one year after the construction to see if good performances fade away, after a short period, once drivers get accustomed with the new street design. Results are once again good, and show that non big differences exist with data recorded just after the construction and performance are somehow even better. The chi square value of 1.23 for a 2 degree of freedom problem (excluding the no interaction case) underlines that in this case no strong relationship exist and the small differences that exist are likely dependant on chance. This results make the speed measurement after one year redundant, since no performance level difference has to be explained.

Table 7: Functional quality of the crossing point

Condition	Step 1	Step 2	Total
No interaction	37%	47%	41%
Uncompleted with interaction	18%	15%	17%
Completed with interaction	45%	38%	42%
Conflicts	0%	0%	0%

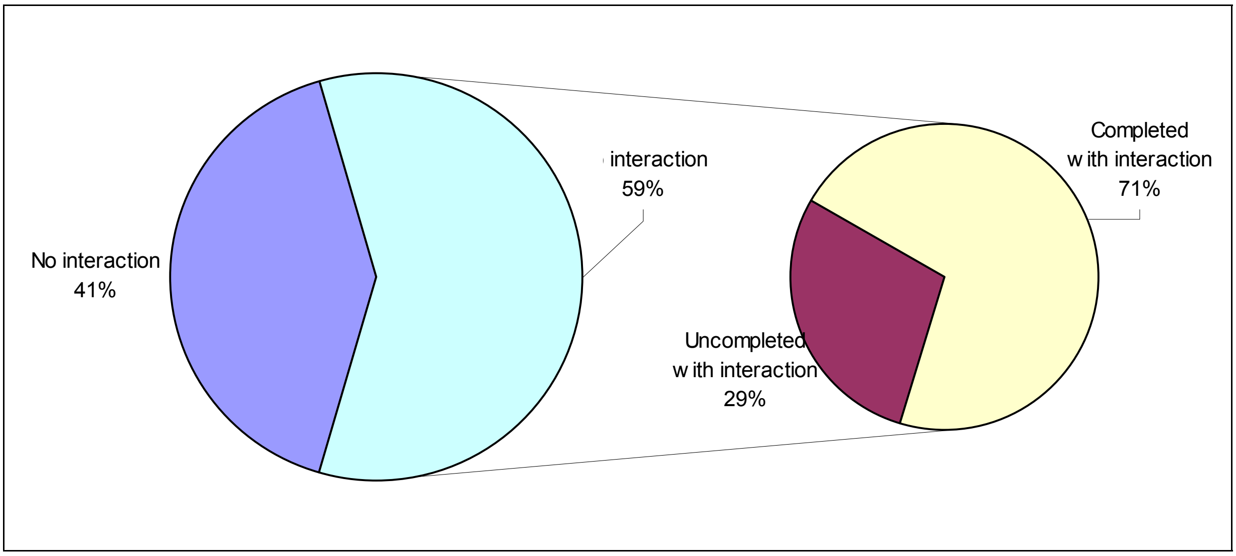

Figure 13: Functional quality of the crossing point chart

Table 8: Comparison of the functional quality of the crossing point one year after its construction

Condition	Just after	1 year after
Uncompleted with interaction	30%	29%
Completed with interaction	67%	71%
Conflicts	3%	0%

CONCLUSIONS

The results obtained with the design of the crossing point are very good, the large majority of the considered parameters show an improvement of the safety condition for pedestrians, moreover results are stable against time. Nevertheless some critics came from some citizens and policemen that see the device as unsafe obstacle for traffic flow claiming that it can be very dangerous for high speed and overtaking drivers, on the other hand high speed drivers are very dangerous by themselves, as a consequence many people are instead very happy with the new crossing facility, which may reduce excessive speed and increase overall safety level, and together with the administrator of the VI Municipio of Rome, are pushing for the extension of such solution to other zones; this extension is very important as optimal performances, in terms o safety and comfort for all users, can be achieved only through organic systems that are able smoothly communicate correct behaviours.

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