Action 6.8.5

Benefit Assessment of Project Profitability (BAPP)

PATRIMONIO CITTÀ DI SETTIMO TORINESE

Project partners

With the contribution of

CONTENT

1. METHODS

The analysis of the profitability of the project benefits as a whole should include an assessment on social, economic and environmental benefits. By doing so it is possible to define possible alternative solutions and assess the real profitability of the work itself.

Main assumption is that maintenance of roads and / or construction of new roads is necessary and required to ensure the good performance of the urban system, to offer good quality services to the public and, last but not least, to safeguard the security of the citizens themselves.

This requires an analysis of the financial side of the use of this new technology in relation to the ordinary maintenance and construction of new roads.

This document comprises three sections:
Section 1 – analysis of the technological solutions adopted and of the related costs in the last 10 years for road pavings in the city of Settimo Torinese
Section 2 - SWOT analysis and cost/benefit analysis of the new technology from the point of view of public administration
Section 3 – main indicators to assess the benefits for public administrations deriving from the uses of ELT rubber powder in road pavings.

2. SECTION 1: DESCRIPTION OF THE STATE IN THE 'SETTIMO TORINESE EXPERIENCE IN ROAD PAVING

The analysis conducted here takes into account the road works carried out over the last 10 years, focussing on paving works in order to allow the comparison with the results of the Tyrec4life project.
The analysis of the work is done by means of a fiche where processes are identified, as well as the Regional Pricelist and the analysis of costs.

ITEM PRICELIST REGION OF PIEDMONT
Funding and lying on the asphalt concrete mat for wearing course, comply with the technical standards city of Turin (16/5/1973 cc), lying in place with paver in a workmanlike manner in accordance with applicable legislation and any indications of D. L., including the burden of static compaction roller or vibrating with constipating effect of not less than 12 tons, excluding the preparation of the ballast below and the generation and spread of bitumen emulsion anchor applied with paver, by one finished thickness compressed equal to 3 cm.

SPECIFICATION
ART.1 WEAR LAYERS
After the realization of the base layer will rest directly the wear layer, after the processing of laying surface via bitumen emulsion, without employing a connecting layer between the two.

a) Description.

The upper part of the road structure will, in general, constituted by a double layer of hot bituminous conglomerate, and precisely: a lower layer connection (binder) and an upper layer of wear, as indicated in the drawings of the project and established by Construction supervision. The conglomerate for both layers will be formed from a mixture of crushed stones, grits, sands and additives (according to the definitions listed in Art. 1 of the << Rules for acceptance of rubble, of crushed stone, of grit, sand, additives for road construction >> the C.N.R., file IV / 1953), mixed with hot bitumen, and will be laid in place by means of vibratory finishing machine and compacted with rubber rollers and smooth.

b) Inert materials.

The taking of samples of inert materials, for the control of the acceptance requirements indicated hereinafter, will be carried out according to the rules C.N.R., Chapter II of IV / 1953 dossier. For the taking of samples for the tests of acceptance control requirements, as well as for how to perform the tests themselves, apply the provisions contained in the dossier IV of the Norms C.N.R. 1953, with the caveat that the test for determining the weight loss will be made by the method Los Angeles according to B.U. Standards C.N.R. n. 34 (28 March 1973) instead of with DEVAL method. The unrefined aggregate (crushed stone and grits) must be obtained by crushing and be constituted by clean, tough, durable, roughly polyhedral, with sharp edges, rough surface elements and free of dust or foreign materials. The coarse

aggregate will consist in crushed stone and grits which may also be sourced or have a petrographic origin of different kinds as long as the tests listed below, carried out on samples responsive to mixture to be trained, meets the following requirements.

For connection layers:

- Weight loss in the test Los Angeles performed on individual pieces according to ASTM C 131 -AASHO T 96, less than 25%;
- Void ratio of the individual pieces, according C.N.R., IV / 1953 dossier, less than 0,80;
- Soaking ratio, according C.N.R., IV / 1953 dossier, less than 0.015;
- Non-hydrophilic material, according C.N.R., IV / 1953 dossier.

In the case that it is planned to subject to traffic the link layer in wet or winter periods, the loss in weight for the shaking will be limited to 0.5%.

For wear layers:

- Weight loss in the test Los Angeles performed on individual pieces according to ASTM C 131 – AASHO T 96, less than or equal to 20%;
- At least a 30% by weight of the entire mixture material must come from rock crushing that have a lower coefficient of crushing 100 and compression strength, according to all the grain orientations, not less than 140 N / mm2, as well as resistance to wear minimum 0.6;
- Void ratio of the individual pieces, according C.N.R., IV / 1953 dossier, less than 0.85;
- Soaking ratio, according C.N.R., IV / 1953 dossier, less than 0.015;
- Non-hydrophilic material, according C.N.R., IV / 1953 dossier, with limitation for the loss in weight to 0.5%;

For the waiting berths aggregates will be employed prescribed for link layers and wear of which above. In any case the rubbles and the grits will have to be constituted by healthy elements, hard, durable, approximately polyhedral, with sharp edges, rough surface, clean and free of dust and strange materials.

The aggregate must be in each case by natural sand or crushing in order to satisfy the requirements of art. 5 of the Rules C.N.R. predicted, and in particular:

- Sand equivalent, determined with the test AASHO T 176, not less than 55%;
- Non-hydrophilic material, according C.N.R., IV / 1953 file with the limitations set for the coarse aggregate.

In case it was not possible to find the size of the material 2 ÷ 5 mm required for the test, the same will have to be done according to Riedel-Weber test mode with concentration not less than 6.

The mineral additives (fillers) will consist of powder of rocks preferably limestone or cement, hydrated lime, hydraulic lime, asphalt dust and must be at the screening by dry completely through a sieve n. 30 ASTM and for at least 65% through a sieve n. ASTM 200.

For the use-surface, at the request of the Directorate of Works, the filler can be made of rock dust asphaltic containing 6 to 8% of bitumen and high percentage of asphaltenes with Dow penetration at 250C less than 150 dmm.

For fillers other than those mentioned above require the prior approval of the Department of Work based on tests and laboratory research.

c) Binder.
The penetration of The bitumen for link and wear layers must be preferably 60 ÷ 70 unless different prescription by the supervision of works in relation to local and seasonal conditions and will have to respond to equal site requirements for the basic mix asphalt.

d) Mixtures.
1) Link layer (binder).
The mixture of the aggregates for the link layer must be a granular composition contained in the following grading limits:

Series sieves and sieves U.N.I	Passing: % Total weight
Sieve 25	100
Sieve 15	65 ÷ 100
Sieve 10	50 ÷ 80
Sieve 5	30 ÷ 60
Sieve 2	20 ÷ 45
Sieve 0.4	7 ÷ 25
Sieve 0.18	5 ÷ 15
Sieve 0.075	4 ÷ 8

The bitumen content must be between 4% and 5.5% based on the weight of the aggregates. It will however be the minimum that allows the achievement of stability and compactness of values Marshall reported below.
The bituminous conglomerate the connection layer must have the following requirements:
- The Marshall stability performed at 60 ° C of compacted specimens with 75 hammer blows per face, will have to result in each case 900 kg or more. Furthermore, the value of the Marshall stiffness, i.e., the ratio between the measured stability in Kg and measured in mm creep, it must be in any case higher than 300. The same specimens for which are determined the Marshall stability must present a voids residues comprised between 3 ÷ 7%. Marshall performed the test on specimens that have undergone a period of immersion in distilled water for 15 days, will have to give a stability value not less than 75% of that previously indicated. With regard to the stability and stiffness measures, both for the bituminous conglomerates type wear for those type binder, the same instructions given for the basic conglomerate.

2) Wear layer. The mixture of the aggregates to be adopted for the wear layer should have a granular composition contained in the following grading limits:

Series sieves and sieves U.N.I	Passing:% Total weight
Sieve 15	100
Sieve 10	70 ÷ 100
Sieve 5	43 ÷ 67
Sieve 2	25 ÷ 45
Sieve 0.4	12 ÷ 24
Sieve 0.18	7 ÷ 15
Sieve 0.075	6 ÷ 11

The bitumen content must be between 4.5% and 6% based on the total weight of the aggregates. The load factor with bitumen of empty inter-granular of the thickened mix must not exceed 80%; the mixture of bitumen content will still be the least appropriate to achieving the Marshall stability and compactness values reported below.
The conglomerate will have to meet the following requirements:

a) high mechanical strength, i.e. ability to withstand without permanent deformation stresses transmitted by the wheels of the vehicles both in dynamic and static phase, even under the highest summer temperatures, and sufficient flexibility to be able to follow in the same settling any commodity and any of the substrate also in the long term; the value of Marshall stability (test B.U. C.N.R. n. 30, 15 March 1973) performed at 60°C on compacted specimens with 75 hammer blows to the face will be at least 100 N [1000 kg]. Furthermore, the value of the Marshall stiffness, that is, the relationship between stability measured in Kg and measured in mm creep, must be in any case higher than 300.The percentage of voids of Marshall specimens, always in the chosen conditions of use, must be between 3% and 6%. The Marshall test performed on specimens which have undergone a period of immersion in distilled water for 15 days, will have to give a stability value not less than 75% of those previously indicated;
b) high surface wear resistance;
c) sufficient of the surface roughness such as to make it not slippery;
d) great compactness: the volume of the residual voids in finished rolling must be between 4% and 8%. To a year after the opening to traffic, the volume of the residual voids must instead be between 3% and 6% and virtually complete impermeability; the permeability coefficient measured on one of Marshall specimens, referring to the chosen conditions of use, in permeameter at constant load of 50 cm of water, it mustn't be under a 10^{-6} cm/sec. Both for bituminous conglomerates for the connection layer which for the wear layer, in the case where the test Marshall is carried out under the control of the conglomerate product stability, the relative specimens will be packaged with the sample material at the production facility and immediately compacted without any further heating. In this way, the compaction temperature will also allow the control of operating temperatures. Since the test shall be performed on the material passing the 25 mm sieve, the same will have to be sieved if necessary.
e) Monitoring of acceptance requirements.

Follow the same instructions given for the base layer.

f) Training and packaging of mixtures.

Apply the same requirements specified for the base layer, except for the minimum effective mixing time, that, with the temperature limits indicated for the binder and the aggregates, must not be less than 25 seconds.

g) Activators accession.

In the box of the asphalt of the various layers can be used special chemical substances, activating the aggregate bitumen adhesion (<< >> dopes adhesiveness). They will be employed in the base layers and the link, and for that of the wear will be to the sole judgment of management:

-when the operation area of the conglomerate, in relation to its geographical position related to closest plants, is so far from the place of production of the conglomerate itself not ensure, in relation to the shipping time of the material, the temperature of 130°C request when stretched

-also when a result of adverse weather situations, the paving of asphalt concretes is not postponed in relation to the demands of traffic and traffic safety. Care should be taken to choose between the products on the market that on the basis of comparative testing carried out at the laboratories authorized you will have given the best results, and who keep their chemical nature even if subjected to high temperatures and prolonged. The dosage may vary depending on the conditions of use, the nature of the aggregates and the characteristics of the product, between 0.3% and 0.6% on the weight of the bitumen. The types, dosages and use techniques must obtain the prior approval of the Project Director. The placing of the activating substances in the bitumen will have to be made with suitable equipment such as ensure its perfect dispersion and the exact dosage.

h) Laying.

The bituminous mixture is spread on the finished surface of the foundation after it has been checked by construction supervision in order to verify the compliance of the latter, the shape, the density and lift indicated in previous articles related to road foundations in granular mix and cement mixed.

Before coating the conglomerate on foundation layers in the mixed concrete, to ensure anchoring, you must remove the sand not withheld from the emulsion bituminous paving previously for the protection cemented itself. Proceeding to the coating in a double layer, the two layers must be overlapped in the shortest possible time and the overlap will be made with at least 30 cm staggered; between them will have to be interposed a bitumen emulsion tack coat type ER 55/60 in the ratio of 0.8 kg /m^2. The laying work of asphalt will be realized by vibratory finishing machines of the types approved by the Works Management, in perfect working order and equipped with automatic self-leveling. The pavers will still leave a perfectly contoured finish layer, without gaps, cracks and free from defects due to segregation of the larger lithic elements. When paving it must take the greatest care to the formation of longitudinal joints preferably obtained through timely tiling of a smear to the previous with the use of 2 or more pavers. Where this is not possible, the edge of the strip already made must be coated with bitumen emulsion to ensure the welding of the next strip. If the board is damaged or rounded it will be necessary to cut vertically with suitable equipment. The transverse joints, resulting from daily breaks, will always be made after cutting and the removal of part of the reset terminal.

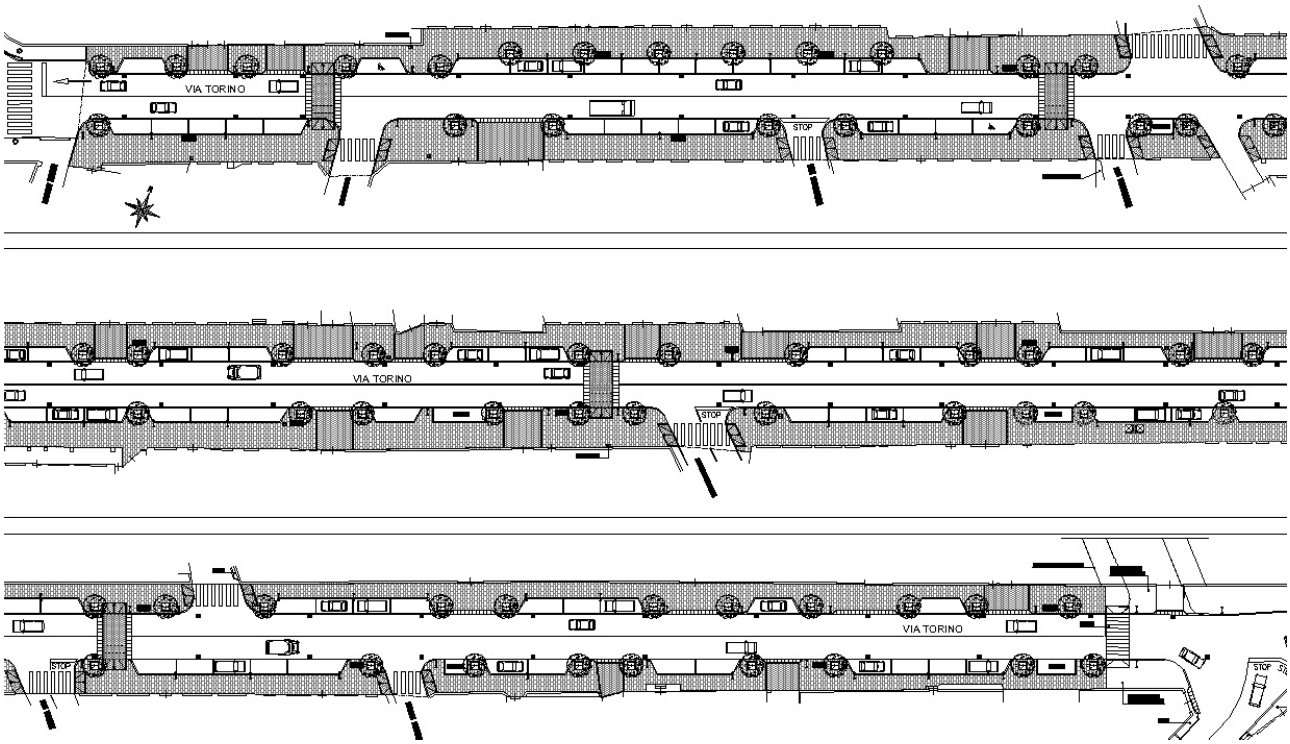
The overlap of the longitudinal joints between the various layers will be planned and carried out in a manner that they prove between them staggered by at least 20 cm . In any case they will be not ever in correspondence of the 2 lane bands normally interested by the wheels of heavy vehicles. The transport of the asphaltic concrete from the plant to the the yard, shall be by adequate capacity transport, efficient and fast and always with covering sheet in order to prevent the excessive cooling surface and formation of crusts. The temperature of the asphalt concrete at the time of spread, checked immediately behind the paver, will have to be in every moment not less than 110 ° C. The paving of the asphaltic concrete will be suspended when the general weather conditions can jeopardize the success of the work; the layers eventually compromise (with densities lower than those required) must be immediately removed and then reconstructed at the expense undertaking. The compaction of the mixes into finished layers of not less than 5 cm and a thickness not exceeding 10 cm. It should begin as soon hung from the paver and run its course without interruption. Compaction will be achieved by

rolling or wheeled vibrated with the assistance of wheeled rollers metal, all in adequate numbers and with appropriate weight and advanced technological features in order to ensure the achievement of the maximum obtainable density. At the end of compaction, the base layer must have a uniform density throughout its thickness. It will also ensure that the compaction is conducted with the most appropriate methodology to obtain uniform compaction at each position and prevent cracking and sliding in the layer just realized. The surface of the layers will be without irregularities and undulations. The finished surface will not deviate from the outline of the project more than 1 cm, controlled by means of a straight edge of m. 4,50 length on two orthogonal directions. All in accordance with the thickness and project templates.

2.1 Adjustment works in via Torino from corso Piemonte to via San Mauro – realization of the I section – from via della Repubblica to via San Mauro

The works included:

- Roadway
  The following elements have been realized along the street targeted by the project:
  - Realization of a two-way street with 3.00 m wide lanes;
  - Realization of in-line parking lots;
  - Realization of a sidewalk with minimum width of 1,50 m
- Pavement
  Paving operations will employ similar material to those already used for previous works of road redevelopment in the historical city centre.
  In particular:
  - Roadway pavements will be composed of a stabilized granular mixture layer, a bituminous mixture layer (*tout-venant* bitumen) and a wearing course on the top;
  - Sidewalks and pedestrian areas will be defined by curbs made of Luserna flame-treated stone and paved with Luserna quarry stone plates laid on a concrete bed with a gravel layer underneath;
  - Public street lighting system;
  - Green areas setup;
  - Urban decoration elements;
  - Drainage network



Cost analysis

	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
ROAD	Escavation 40 cm	4124.66 mq	2.2 €/mq	9074.25 €	
	Pavement breakup 25 cm	4124.66 mq	1.88 €/mq	7754.36 €	
	Layer wearing 3 cm	4124.66 mq	3.05 €/mq	12580.21 €	
TOTAL				**29408.82 €**	**7.13 €/mq**

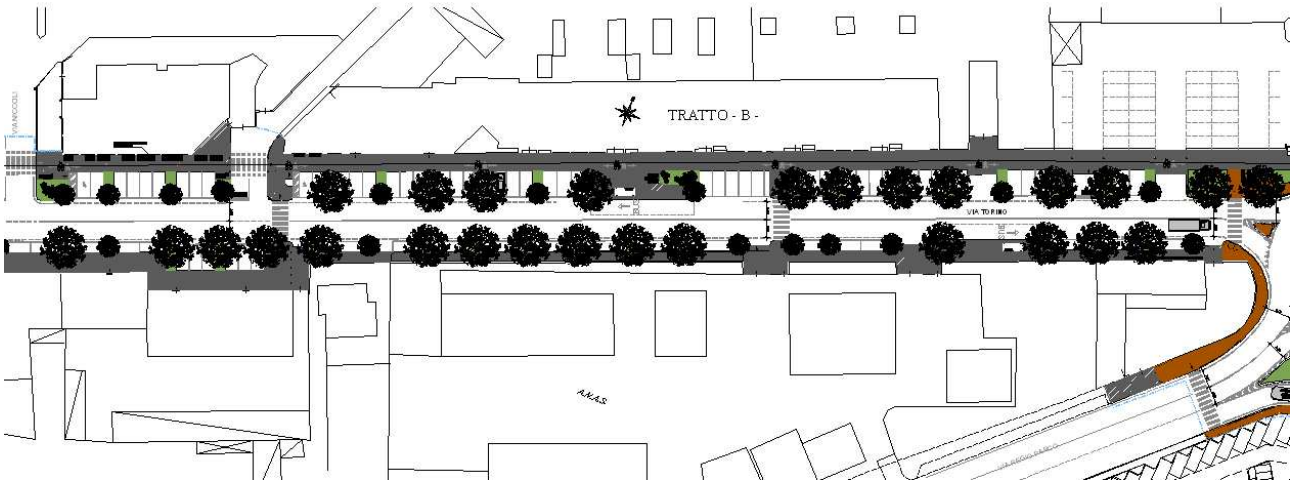
2.2 Adjustment works of via Torino in the section comprised between via San Mauro and via Sanzio – realization of the II section – part B

This activity included the following works and services:

- Temporary and/or permanent reinstatement of street pavements and sidewalks existing prior to the beginning of the works as per the instructions of the Works Supervision;
- Obligations connected to the demarcation of the construction site in agreement with the regulation on work safety and the road traffic codes;
- Cutting operations realized with tools including diamond-cut tools and/or demolition and/or removal of possible road pavement of any thickness and type, as well as pre-existing brickworks and artefacts in the site;
- Excavations works with fixed section and in grounds of any nature and consistency for the setup of laying trenches for conduits and annexed elements, including the regulation – realized with tools or manually – of the bed and the creation of recesses;
- Disposal in public landfills of excavation materials exceeding the covering and filling needs or not suitable for said purposes; transfer to temporary storage locations, setup under the responsibility of the contracted company, of excavation materials that could not be left on site according to the Works Supervision; subsequent collection of such materials, transfer and employment as cover and fill in the excavation works. Cutting, packaging and transport operations all followed the instructions provided by the Law and by the Regional Agency for Environmental Protection (ARPA) in case of possible concrete – asbestos;
- Laying conduits and annexed special components in trenches; setup and accommodation, realization of joints, external coating reinstatement.

Roadway pavements will be composed of a stabilized granular mixture foundation layer, an intermediate bituminous mixture layer (binder - *tout-venant* bitumen) and a wearing course on the top.

The roadway in the section comprised between Corso Agnelli and Corso Piemonte (action plan B as per the graphics), between the two roundabouts, respectively referred to operations A and C, will be a two-way driving road with 3.50 m wide lanes.



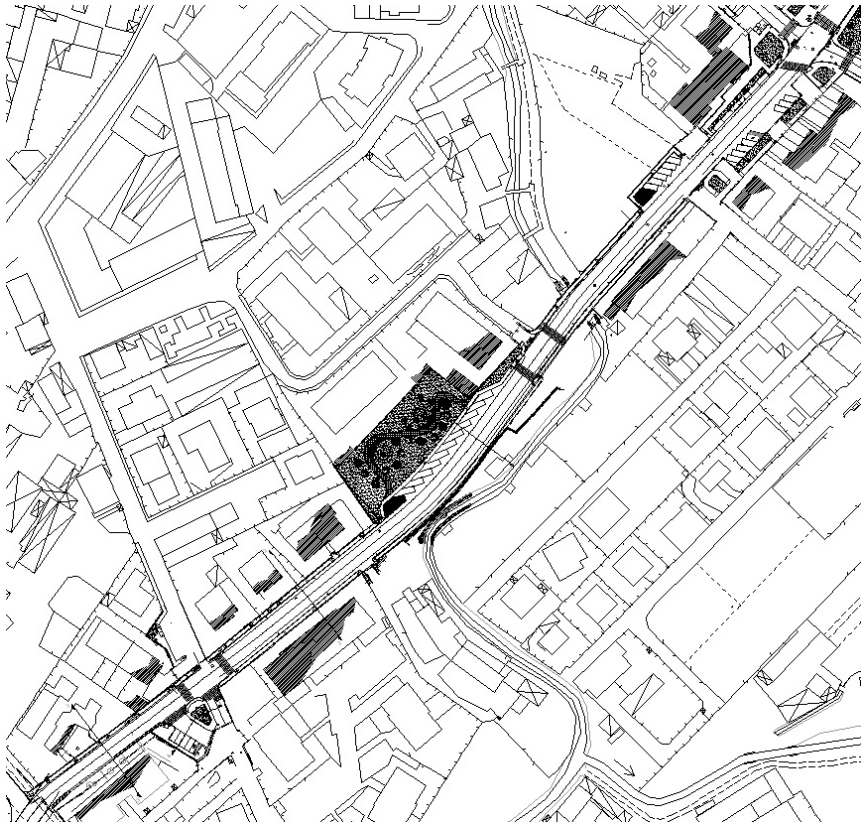
Cost analysis

	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
ROAD	Scarifying 3 cm	2801.5 mq	4.23 €/mq	11850.3 €	
	Bitumen emulsion	3271.68 mq	0.59 €/mq	1930.29 €	
	Layer wearing 3 cm	3271.68 mq	3.26 €/mq	10665.688 €	
TOTAL				**24446.27 €**	**7.47 €/mq**

2.3 South axis – adjustment works of via Volta, via Palestro and piazza Donatori, and completion of via Fosse Ardeatine – realization of the I section, I extract

The activity to be realized includes:

1. Realization of pedestrian routes in agreement with the current regulation and complying with the guidelines for the removal of architectural barriers;
2. Realization of a two-way road section between Via Gribaudia and Via G. Guarini; realization herringbone parking areas;
3. Realization of a new two-way road section to complete Via Fosse Ardeatine (on the side of De Gasperi Park)
4. Setup of an equipped green area;
5. Regulation of the road section comprised between Via G. Guarini and Via Vagliè.



The programmed operations are:

- *Excavation and filling*:

- *Street pavement*: the existing road sections will be subject to scarification and bituminous colloid cover, after which a new wearing coarse layer will be posed. The sections thus implemented will be consist of:

  Road package of 56 cm for new pavements composed of:

- anhydrous granular mixture with compressed thickness equal to 20 cm;
- stabilized concrete granular mixture with compressed thickness equal to 20 cm;
- bituminous granular mixture (treated *tout-venant* mixture) with compressed thickness equal to 8 cm;
- intermediate bituminous concrete layer (binder) with a finished thickness of 5 cm;
- bituminous concrete wearing coarse with a finished thickness of about 3 cm;

Bituminous concrete wearing coarse laid on a layer of bituminous colloid and, in the section comprised between Via Vagliè and Via Boves, the addition of an intermediate bituminous concrete layer (binder) to match the project plans.

- Pedestrian routes;
- Drainage network;
- Public street lighting system;
- Road signs;
- Additional works: decoration, green areas, irrigation.

Cost analysis

ROAD	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
NEW ROAD	Escavation 50 cm	1650 mq	1.13 €/mq	1872.75 €	
EXSISTING ROAD	Scarifying 4 cm	3065 mq	5.27 €/mq	16152.5 €	
	Bitumen emulsion	4865 mq	0.63 €/mq	3064.95 €	
	Layer wearing 3 cm	1585 mq	3.36 €/mq	5325.6 €	
	Layer wearing 4 cm	1020 mq	4.46 €/mq	4549.2 €	
TOTAL				**36583.25 €**	**11.88 €/mq**

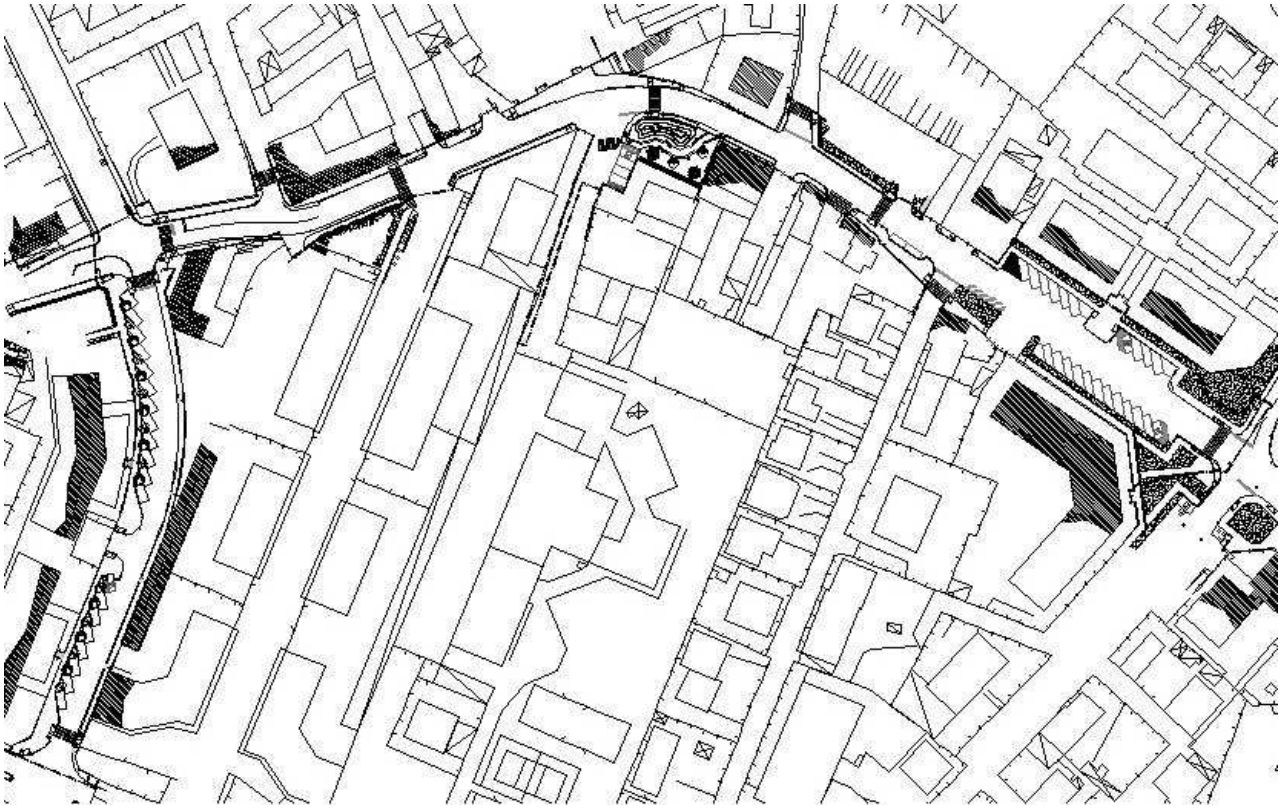
2.4 South axis – adjustment works of via Generale Dalla Chiesa and via Volta (in the section comprised between via Generale Dalla Chiesa and via Vaglie') - realization of the I section, II extract

The objectives of this activity are:

- Realization of a main one-way road and oblique parking areas along the section of Via Generale Dalla Chiesa between Via Piave and Via Volta;
- Realization of new sidewalks and enlargement of existing pedestrian routes in agreement with the regulation for the removal of architectural barriers;
- Regulation of the road section comprised between Via Goito and Via Arduino d'Ivrea;
- Enlargement of the road site in the section of Via Volta between the access to the secondary school Calvino and Via Colombatto;
- Re-distribution of the parking areas in the existing parking lots along Via Volta beween Via Arduino and Via Colombatto;
- Realization of an equipped green area and 5 oblique parking areas in the junction between the access to the the secondary school Calvino and Via Volta.

The programmed operations are:

- Excavation and filling;
- Street pavement: the existing road sections will be subject to scarification and bituminous colloid cover, after which a new wearing coarse layer will be posed;
- Pedestrian routes;
- Drainage network: completion and adjustment of the existing network;
- Public street lighting system;
- Road signs;
- Additional works: decoration, green areas, irrigation.



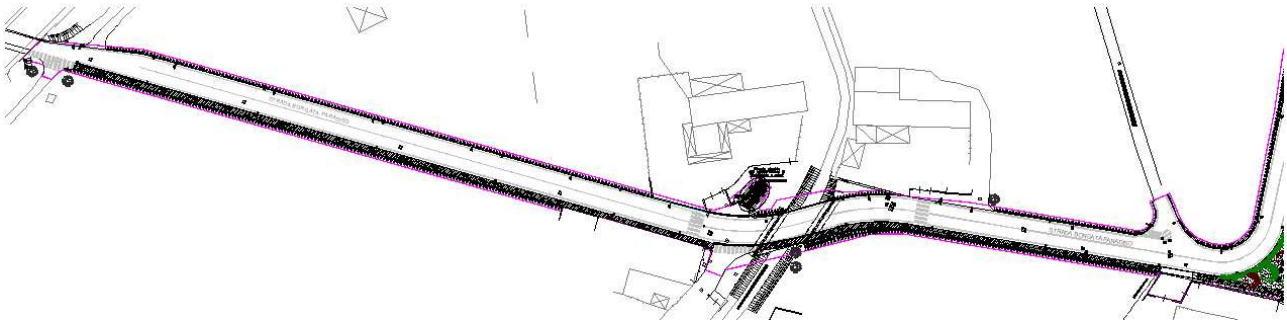
Cost analysis

ROAD	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
	Escavation 15 cm	623 mq	8.93 €/mq	5563.4 €	
	Scarifying 4 cm	4547 mq	4.46 €/mq	20279.6 €	
	Bitumen emulsion	5316 mq	0.43 €/mq	2285.9 €	
	Layer wearing 3 cm	4923 mq	3.36 €/mq	16541.3 €	
TOTAL				**44670.2 €**	**9.07 €/mq**

2.5 Road access to Borgata Paradiso

The activity to be realized includes:

- Realization of a roadway and car park: an anhydrous granular mixture with thickness of 20 cm will be followed by a stabilized concrete granular mixture with finished thickness equal to 20 cm. On the top of the foundation layers there will be 3 layers of flexible pavement made of bituminous mixtures:
  - A 10 cm thick base *tout-venant* layer;
  - A 5 cm thick intermediate binder;
  - A final 4 cm thick wearing coarse
- Realization of pedestrian routes;
- Realization of the new road overpass of Rio Freidano;
- Realization of a new drainage network;
- Deviation of a section of black sewage lines;
- Deviation of a section of aqueduct;
- Deviation of a section of medium and high voltage ENEL energy distribution network;
- Cover of the existing the current TELECOM aerial line;
- Renovation of the public street lighting system;
- Installation of an irrigation system and adjustment of the green area;
- Reinstatement and integration of vertical and horizontal road signs.



Cost analysis

ROAD	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
	Escavation	2289.52 mq	2.31 €/mq	5288.79 €	
	Pavement breakup	1140.55 mq	9.22 €/mq	10515.87 €	
	Bitumen emulsion	4046.07mq	0.69 €/mq	2791.79 €	
	Layer wearing 4 cm	4046.07mq	4.65 €/mq	18814.23 €	
TOTAL				**37410.68 €**	**9.25 €/mq**

2.6 New P.R.G.C. road (a road realized under the Municipality General Regulation Plan) connecting via Giacosa and via Rio Fracasso

The activity to be realized includes:

- ✓ Realization of a new roadway with a 3.50 m wide lane and herringbone parking areas of 5 m inclined by 60 degrees compared to the longitudinal axis from the side of the buildings; in-line parking spaces measuring 2.00 m by 5.00 m along will be realized on the opposite side of the roadway;
- ✓ Realization of new sidewalks with minimum width of 2.00 m (except for a section of Via Rio Fracasso) with pressed concrete curbs and 3 cm thick bituminous paving, renovation and rearrangement of the public street lighting poles;
- ✓ Realization of in-line and oblique car parks along Via Fracasso and Via Giacosa measuring not less than 2.00 m by 5.00 m;
- ✓ Adjustment of the existing roadways in Via Rio Fracasso and Via Giacosa;
- ✓ Adjustment of the sub-services networks; extension of the drainage network; renovation of the public street lighting system in Via Rio Fracasso and Via Giacosa;
- ✓ Shifting of Rio Fracasso towards South, now running in parallel to the roadway, and filling of the river bed.

The programmed operations are:

- *Excavation and filling;*
- *Street pavement*: roadway paving will be composed as follows:

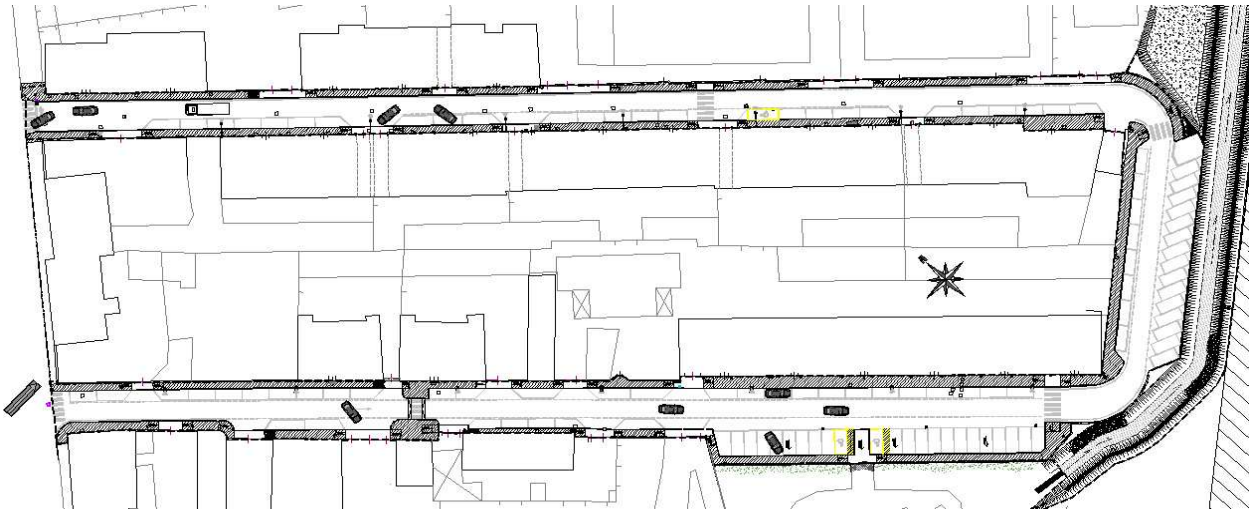
  For new pavements:

  - anhydrous granular mixture for road foundations with minimum thickness equal to 20 cm;
  - stabilized concrete granular mixture with compressed thickness equal to 15 cm;
  - bituminous granular mixture (treated *tout-venant* mixture) with compressed thickness of 8-10 cm;
  - bituminous concrete wearing coarse with a finished thickness of about 3 cm;

  In the proximity of the new pedestrian routes the base (*tout-venant*) layer will be reinstated and covered with a wearing coarse. A scarification of 4 cm and the reconstruction of the wearing coarse is programmed to match the current traffic conditions.

- *Pedestrian routes;*
- *Drainage network*: completion and adjustment of the existing network;
- *Public street lighting system*: adjustment and extension of the current system, with new lights in the new road section;

- *Road signs*;
- *Additional works*: *decoration, green areas, irrigation:*
- *Reshaping operations of Rio Fracasso.*



Cost analysis

ROAD	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
NEW ROAD	Escavation 50 cm	886 mq	1.15 €/mq	1023.33 €	
	Escavation 15 cm	205 mq	1.19 €/mq	245.38 €	
EXISTING ROAD	Scarifying 4 cm	2414mq	5.42 €/mq	13083.88 €	
	Bitumen emulsion	1495.5 mq	0.69 €/mq	1031.9 €	
	Layer wearing 4 cm	1495.5 mq	4.65 €/mq	6954.08 €	
TOTAL				**22338.57 €**	**14.93 €/mq**

2.7 Adjustment works in via Consolata

The activity to be realized includes:

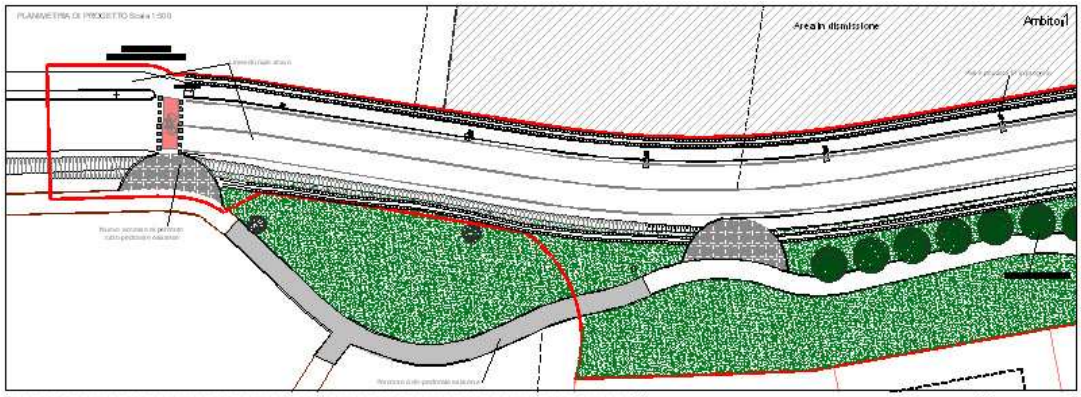
Excavation and filling:

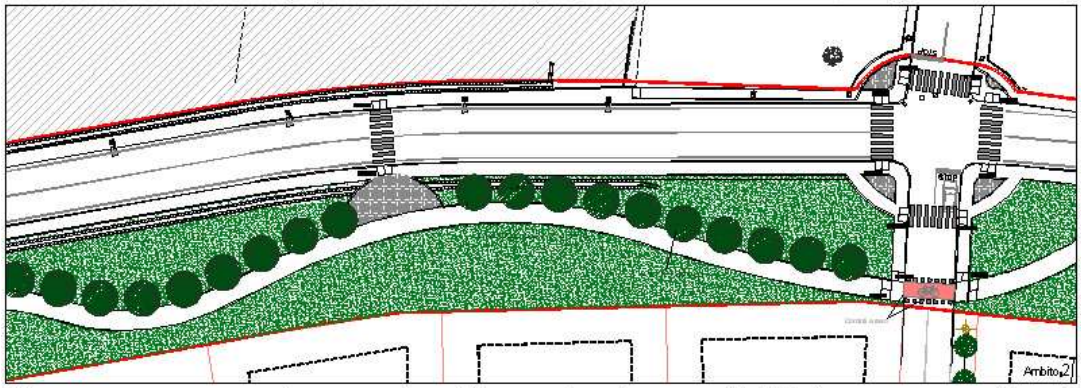
- In order to regulate the road cover and expand the current road section, the following operations are programmed:
- Scarification of the section comprised between Via Frassati and Via Provana;
- Excavation at different levels and, where necessary, realization of a new road package starting from the deepest foundation layer.

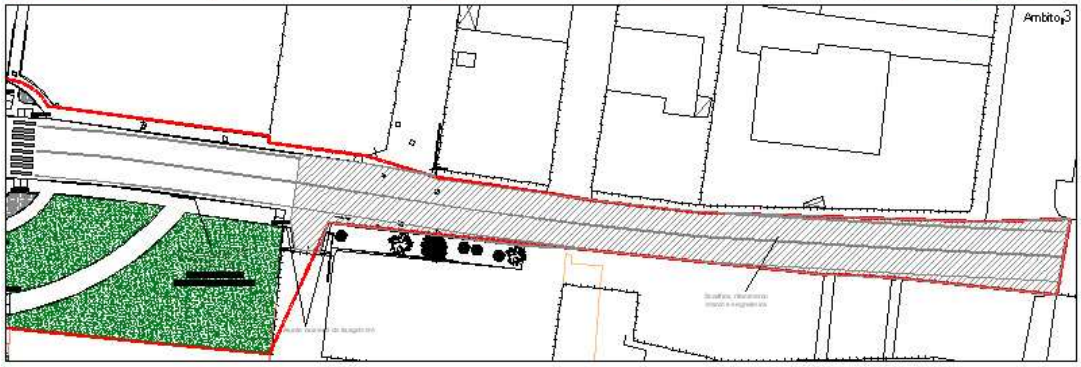
Street pavement: the roadway paving will be composed as follows:

- An **under-foundation** layer of non bound anhydrous granular mixture with a thickness of 20 cm;
- A **foundation** layer of stabilized concrete granular mixture with a thickness of 20 cm;
- A **base** layer of bituminous granular mixture (treated *tout-venant* mixture) with a thickness of 12 cm;
- A **wearing coarse** with a thickness of 3 cm protecting the layers underneath.

- *Sidewalks, bicycle and pedestrian routes;*
- *Horizontal and vertical road signs*;
- *Green areas setup;*
- *Drainage network;*
- *Public street lighting system*: adjustment and extension of the current system, with new lights in the new road section;
- *Reshaping operations of Rio Fracasso.*







Cost analysis

ROAD	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
	Escavation 35 cm	2762 mq	4.86 €/mq	13424.06 €	
	Pavement breakup	1420 mq	9.22 €/mq	13092.4 €	
	Scarifing 5 cm	905 mq	6.24 €/mq	5647.2 €	
	Bitumen emulsion	3388 mq	0.69 €/mq	2337.72 €	
	Layer wearing 3 cm	3388 mq	3.50 €/mq	11858 €	
TOTAL				**46359.38 €**	**13.68 €/mq**

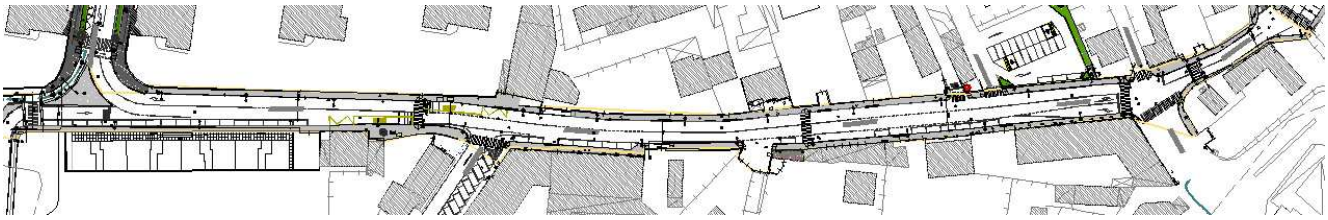
2.8 Redevelopment works in via San Mauro: urban section between corso Agnelli and viale Piave

The programmed operations are:

- *Street pavement*: the final bituminous pavement will be realized as follows: bituminous mixture wearing course (4 cm thickness), following overlay of base/binder course in limited areas;

- *Pedestrian routes;*

- *Green areas*: the project includes the setup of flowerbeds and hedges;
- *Drainage network:* completion and adjustment of the existing network;
- *Public street lighting system*: the project includes the replacement of the existing system located on one side of the road with a new one that has shorter poles located on both sides of the road;
- *Road signs*;



Cost analysis

	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
ROAD	Scarifying 4 cm	5055 mq	5.91 €/mq	29875.05 €	
	Bitumen emulsion	4687.1 mq	0.46 €/mq	2156.06 €	
	Layer wearing 4 cm	4687.1 mq	4.65 €/mq	21795.06 €	
TOTAL				**53826.17 €**	**11.48 €/mq**

2.9 Priority works in zone 30 "CENTRE" of the project n.3: via Ariosto/Castiglione, urbanization in the framework of QT3

The activity to be realized includes:

- *Excavation and filling:*

The main operations required for the realization of the new road package can be summarized as follows:

- Minimum excavation works to dig underneath compacted layers fit to host, where programmed, the new road package;
- Reuse of the excavated material recovered from said operations that can be employed for the realization of foundation layers of non-bound composition and a thickness equal to about 35 cm;
- Compaction of the foundation layer described above for the preparation of the subsequent wearing coarse.

- *Street pavement*

The project plans to proceed with excavation and scarification works diversified according to the goals of each site. The new road package will thus have a stratigraphy composed as follows:

- Road foundations made of an anhydrous granular mixture and stabilized concrete granular mixture (whereas not already in place and unchanged by the project plans) with a superstructure made of a granular bituminous (*tout-venant*) mixture for the possible creation of new cross cutting slopes and the achievement of the benchmarks set by the project, and a subsequent laying of a bituminous concrete wearing coarse of 4 cm;
- In the areas there the foundations are consolidated (e.g. former green or pedestrian areas), the pavement will consist in a structure and superstructure with the following features: maximum thickness of 50 cm (pavement package made of a foundation layer of anhydrous granular mixture with maximum thickness equal to 20 cm + stabilized concrete granular mixture layer of 15 cm + *tout-venant* layer of 10-15 cm + wearing coarse of 4 cm)

- *Pedestrian routes;*
- *Cycling route;*
- *Crossroads and realization of "Access points zone 30"*
- *Horizontal and vertical road signs*;
- *Drainage network;*
- *Public street lighting system*:
- *Protection and decoration elements*

Cost analysis

ROAD	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
NEW ROAD	Escavation 50 cm	482 mq	16.6 €/mq	8001.2 €	
EXISTING ROAD	Escavation 35 cm	147 mq	14.3 €/mq	2102.1 €	
	Scarifying 4 cm	2830 mq	5.91 €/mq	16725.3 €	
	Bitumen emulsion	3329 mq	0.69 €/mq	2297.01 €	
	Layer wearing 3 cm	3329 mq	3.50 €/mq	11651.5 €	
TOTAL				**40777.11 €**	**12.25 €/mq**

2.10 Renovation of viale Piave in agreement with the priority works planned for zone 30 "CENTRE"

The activity to be realized includes:

- *Excavation and filling:*

The main operations required for the realization of the new road package (if planned) can be summarized as follows:

- Minimum excavation works to dig underneath compacted layers fit to host, where programmed, the new road package;
- Reuse of the excavated material recovered from said operations that can be employed for the realization of foundation layers of non-bound composition and a thickness equal to about 35 cm;
- Compaction of the foundation layer described above for the preparation of the subsequent wearing coarse.

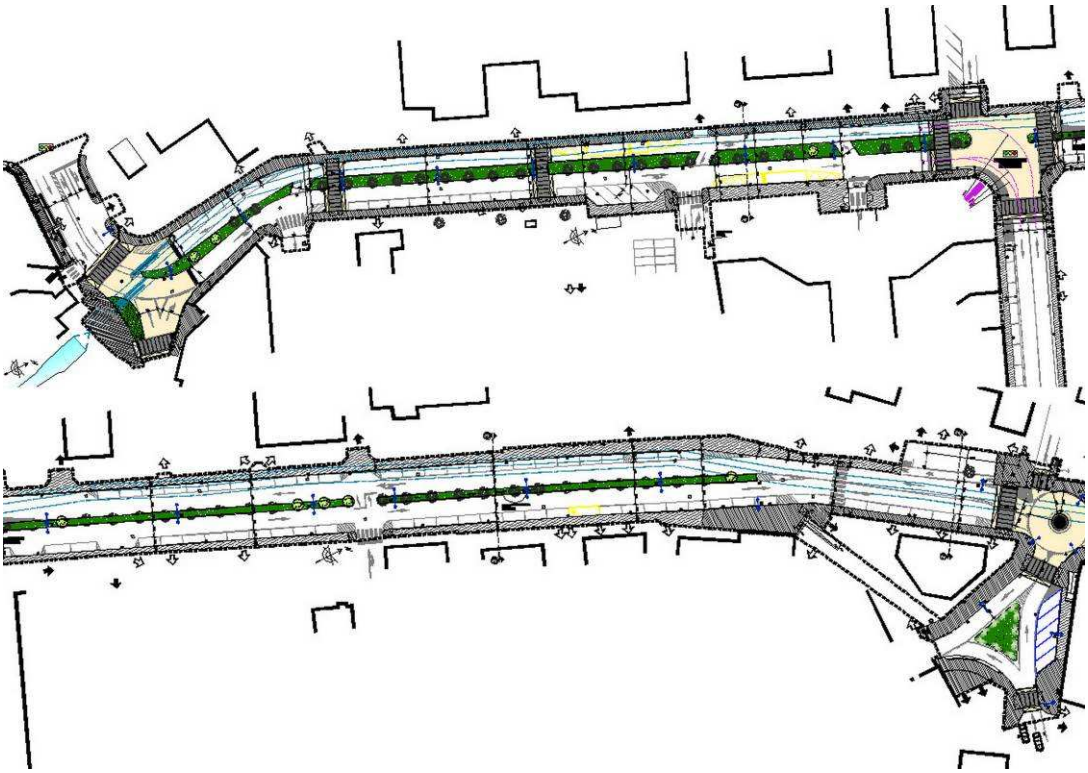
- *Street pavement*

The project plans to proceed with excavation and scarification works diversified according to the goals of each site. The new road package will thus have a stratigraphy composed as follows:

- Road foundations made of an anhydrous granular mixture and stabilized concrete granular mixture (whereas not already in place and unchanged by the project plans) with a superstructure made of a granular bituminous (*tout-venant*) mixture for the possible creation of new cross cutting slopes and the achievement of the benchmarks set by the project, and a subsequent laying of a bituminous concrete wearing coarse of 4 cm;
- In the areas there the foundations are consolidated (e.g. former green or pedestrian areas), the pavement will consist in a structure and superstructure with the following features: maximum thickness of 50 cm (pavement package made of a foundation layer of anhydrous granular mixture with maximum thickness equal to 20 cm + stabilized concrete granular mixture layer of 15 cm + *tout-venant* layer of 10-15 cm + wearing coarse of 4 cm)

- *Sidewalks;*
- *Lifted crossroads and realization of "Access points zone 30"*
- *Public transport stations*
- *Horizontal and vertical road signs*;
- Green areas and car park
- Irrigation system

- *Drainage network;*
- *Public street lighting system and modification of the traffic lights system*
- *Protection and decoration elements, additional works*



Cost analysis

	WORKS	SURFACE	UNIT COST	TOTAL COST	PARAMETRIC COST
ROAD	Scarifying 3 cm	7380 mq	5.22 €/mq	38523.6 €	
	Bitumen emulsion	9789 mq	0.55 €/mq	5383.95 €	
	Layer wearing 3 cm	7715 mq	4.11 €/mq	31708.65 €	
TOTAL				**75616.2 €**	**9.80 €/mq**

3. SECTION 2: SWOT ANALYSIS

STRENGHTS	WEAKNESSES
Physical and environmental issues • Reduction of the production of waste that must be disposed of in landfills • Reduction of urban traffic noise **Economic issues** • Reduction of scrap tyres disposal costs • Reduction of the use of sound barriers **Social issues** • Improvement of urban life quality standards • Reduction of accidents **Public policies** • Strengthening of reuse policies • Strengthening of environmental policies	**Physical and environmental issues** • Difficulties of paving operations in urban context **Economic issues** • Limited demand of products realized with crumb rubber from scrap tyres • Urban road maintenance realized for small interventions **Social issues** • Advantages of the new paving system not perceived **Public policies** • Scrap tyres cycle not directly controlled by local Administrations • Environmental policies focusing only the enhancement of naturalistic aspects
THREATS	**OPPORTUNITIES**
Physical and environmental issues • Limited reuse of crumb rubber from scrap tyres **Economic issues** • Lack of demand for products made of crumb rubber • Impossibility of reducing production costs **Social issues** • Marginal reduction of noise perceived by local residents **Public policies** • Inconsistency of public actions aimed to encourage the use of crumb rubber	**Physical and environmental issues** • Reduction of noise disturbances in urban centres • Lower amount of crumb rubber is incinerated **Economic issues** • Development of a new production chain • Reduction of industrial waste disposal costs **Social issues** • Higher awareness on the possibility of materials reuse • Improvement of urban life quality conditions **Public policies** • Joint management and effective governance of reduction and reuse processes for industrial waste

3.1 Strengths

Physical and environmental issues

Starting from the VI Action Program for Environment, all the strategic acts and regulations of the European Union consider the sustainable use of natural resources a priority goal and connect it to sustainable waste management.

In the Communication of 26th January 2011, the European Commission stated that it is not possible to pursue our current resources exploitation models any further, as the intensive employment of the world's resources, especially the non renewable ones, that has been perpetuated in the past decades causes pressures on the planet and threatens supply security. A more efficient use of resources will have a crucial importance for growth and employment trends in Europe, tackling these challenges, and it will provide new great opportunities for economy as well as improve productivity, reduce costs and empower market competition. The same framework involves the minimization of waste products which will bring improvements in the management of resources and modifications to the current consumption models. A preliminary analysis of the current situation appears rather alarming: today an average EU citizen consumes 16 tonnes of materials every year, out of which 6 tonnes are wasted (and half of this amount ends up in landfills).

A mix of tools and actions must be set in place so that waste will be managed as a resource by 2020; this implies:

- Stimulating secondary material markets and the demand of recycled goods through economic incentives and criteria that put an end to the production of new waste;
- Re-assessing the existing goals in the fields of prevention, reuse, recycling, recovery and alternative disposal options to landfills aiming to an economy based on reuse and recycling, with the almost complete elimination of residual waste;
- Considering the introduction of minimum benchmarks for recycled material, durability and reusing potential criteria, and the empowerment of the producer's responsibility for all main products;
- Pursuing collaboration within the EU and with international partners in order to eliminate the illegal transfer of waste, with a special regard to hazardous categories of waste;
- Ensuring that the EU public funding prioritizes the activities targeting the higher levels of the waste hierarchy (such as recycling facilities).
-

These premises standing, the use of crumb rubber deriving from scrap tyres for street paving is a clear strength in line with European and national policies for the limitation of the exploitation of environmental resources.

Another strength is the reduction of traffic noise; preliminary experiences conducted in Imola, Pistoia and Florence demonstrated a good appreciation of the local population, which was able to perceive the reduction of noise in the areas where crumb rubber mixtures were employed. A confirmation of what was assessed in Tuscany in 2007 comes from a project of the Autonomous Province of Bolzano launched in 2011 with the objective of testing the actual reduction of noise

emission levels obtained thanks to the use of asphalt pavements modified with crumb rubber. This project highlighted an actual traffic noise reduction.

Economic issues

Producing a tonne of crumb rubber requires about 10 tonnes of scrap tyres that should otherwise be disposed of; it's clear that such an amount of material would not be reused and must be trasnferred to a landfill site for a cost ranging from 10 to 20 euro per tonne. While the current regulation prohibits the disposal of tyres in landfills, it does allow their energy recovery.

The report "L'Italia del riciclo 2011" ("*Italy recycles 2011*"), realized by Fondazione per lo Sviluppo Sostenibile (Foundation for Sustainable Development) and Fire Unire – Unione Nazionale Imprese Recupero (National Union of Recovery Companies) confirmed that unfortunately our country does not match the European trends. Although 48% of all scrap tyres are treated for energy recovery, the rate of actual material recovery does not compensate the equation and the percentage of material that is not managed remains too high (26%).
The economic consistency of the operation is demonstrated by the outcomes of *ex-post* cost analysis carried out by the Road Department of the Autonomous Province of Bolzano, which confirmed the competitive potential of crumb rubber pavements compared to the hypothetical installation of sound barriers.

Social issues

Applying new technologies to street paving is a strength in terms of safety and environmental impacts in the urban and non-urban context. Highway sections where water does not bounce on the car windshield and visibility remains good even in rainy conditions, for instance, are paved with draining asphalt whose open pattern allows water to pass through, thus reducing accidents up to 20%.
The characteristics of crumb rubber mixtures include improved drainage, better adherence, sound absorption (rubber is a sound absorbing material), energy and natural resources saving (the rubber employed as primary material is recovered).
The improved efficiency of vehicles depends on the pavement patter and its roughness. Adherence is connected to the choice of stone mixtures, the kinds of stones combined with crumb rubber, which ensures a better road holding.
Finally, the reduction of background noise deriving from traffic is an important element for urban life quality.

Public policies

Public institutions find a strength in using new materials and new technologies that improve the quality of the services they provide to citizens. The Municipality of Settimo Torinese has been implementing policies of the improvement of urban environment for years; as an example, in the past 10 years it realized over 1 million square meters of parks by planting more than 15.000 trees, and in 2008 it introduced the urban door-to-door separated waste collection system.

Starting from these policies it becomes clear that any technology aiming to the reduction and to the reuse of waste is a strength in terms of improvement of the Administrations' skills in

pursuing actions that raise citizens' awareness over the importance of healthy urban environments and, in general, that maximize the reuse of end-of-cycle materials.

3.2 Weaknesses

Physical and environmental issues

Strictly speaking, from the environmental point of view there are no weaknesses. However, there are physical elements that must be considered within the urban structure and its specific features, with special regard to older urban centres where streets appear less regular, with different manholes, recesses and driveway accesses that make paving operations more complicated and where it is often necessary to work "manually" on the pavement in order to ensure complete cover of the street surface.

This condition, together with the fact that bituminous asphalt realized with the addition of crumb rubber requires a higher attention to laying temperatures, makes this product harder to employ in urban contexts.

Economic issues

One of the problems encountered by the reuse of products realized with crumb rubber derived from scrap tyres is the competition with other similar products already circulating in the market and their poor visibility.
The use of products realized with this material ranges from construction material to street pavements; the main products currently available are:

- Sport surfaces (as filling material for artificial turf fields and athletics rings, shockproof pavements and riding grounds)
- Soundproof material (acoustic panels, anti-noise carpets, waterproof membranes, anti-vibration materials)
- Urban decoration, pavements and artefacts
- Fuel for concrete factories
- Mulching material
- Modified asphalt

Unfortunately a regulation that is not particularly encouraging ecologic purchases of public Administration confines the size and the possible developments of the market of these products. Concerning street paving, in particular, the market faces two difficulties: on one side bituminous mixtures with crumb rubber are produced by a single company in Italy which sets the price without margins for negotiation since there is no competition; on the other side regional price lists do not include this product yet and, being precautionary, public Administrations do not use non-listed products.

Social issues

One of the main weaknesses of each public action is the difference between what can be scientifically assessed and what single citizens can perceive.

On the technical level we report the experience of the Municipality of Settimo Torinese that carried out traffic analysis in order to assess the number and speed of vehicles driving along exclusively residential areas and verify the notifications of safety hazard conditions for pedestrians due to excessive speed of cars.
Measurements detected that only 15% of the vehicles exceeded the speed of 30 km/h and only 1% exceeded the limit of 50 km/h.
This experience showed that the perception of citizens was not connected to the actual danger posed by traffic, but by their own expectations about it. Similarly, traffic noise might feel higher than the actual decibel value assessed.

Public policies

As for the weaknesses connected to public policies, we must consider that local Administrations are directly responsible only for urban waste collection services but they are not involved in the policies on the collection of special waste.
In addition to this, citizens are inclined to consider waste a problem solved when their dustbins are emptied.
Therefore the real weakness is concealed in the fact that local Administrations focus their environmental actions on the best possible management of urban waste and on naturalistic interventions.

3.3 Threats

Physical and environmental issues

Not reusing crumb rubber is a possible threat for environment because it can be used as cheap fuel, such as in concrete factories.
In general terms, although concrete factories burning waste (from RDF, tyres, solvent, etc) state that this procedure reduces their sulphur dioxide emissions compared to the use of fossil fuels (coal or oil), the pollution problem does not concern only SO_2, but also dioxins, furans, PCB, heavy metals, particulate matter, nitrous oxide and several other components that are produced when burning rubber and plastic. Most of these substances are known as extremely toxic (they contain PCB, dioxins, heavy metals such as Hg, Cd, Pb, Cr and other contaminating elements) whose presence in waste fuel generates severe health and environmental impacts.
Moreover concrete factories have been granted benchmarks of emissions that are much more tolerant than those assigned to the incinerators of hazardous of RSU waste products. This special condition is true only for a certain category of contaminating agents: the worst ones.
Concrete factories managements affirm their furnaces operate disposal functions in a more efficient way compared to the incinerators of hazardous waste. In fact they burn at higher temperatures (the average being 1400°C and the maximum 2000°C) and have a permanence time (timeframe when waste is in the furnace) of at least 5 seconds compared to the 2 seconds of the incinerators. However, even if the operative temperature in some parts of a furnace can be higher than in an incinerator, this is not enough for ensuring the correct combustion of PFU: as a matter of fact, the mix of air and combustible material in a furnace is lower, resulting in lower efficiency of the process because it is less homogeneous, therefore inadequate. As a consequence, dioxins, furans and PCB – which are all harmful for health – are constantly produced in the chemical reactions together with large quantities of hydrochloric acid within the plants and eventually spread out of their chimneys.

Economic issues

Today crumb rubber from scrap tyres is not employed as a normal material within industrial production processes, only a few companies building their brand on eco-sustainability use it.
On the topic of the national recovery chain, the aforementioned report "L'Italia del riciclo 2011" ("*Italy recycles 2011*") highlights that, while the distribution of mechanical treatment and chipping companies (over 90 in 2010) is higher than the actual treatment needs, the scarce activities employing recovered materials represents one of the main criticalities that cause a "chronic condition of difficulty in this sector".

The clear threat is that, unless the market responds positively to this offer – which is currently presenting products that are very similar, but more expensive than those already existing – it will be impossible to create a stabile demand and, consequently, it will not be cost-efficient to keep the production going.

Social issues

Although positive effects on the reduction of noise pollution have been assessed, there isn't any long-term analysis in the scientific literature on the beneficial impacts on acoustics, in particular in urban centres and residential areas where traffic is lower. The reduction could not be perceivable enough to impose the choice of this product instead of other cheaper solutions.

Public policies

The lack of a specific national or European policy forcing Administrations to favour crumb rubber street pavements derived from scrap tyres can lead to indifference in local Administrations towards using this kind of paving, resulting in the use of consolidated and cheaper techniques.

3.4 Opportunities

Beyond weaknesses and threats, there are several opportunities deriving from the strengths and they should not be missed. In particular, they ensure a higher sustainability both of the automotive market and of the public Administrations.

Physical and environmental issues

First of all, the development of this project presents opportunities for environmental aspects and is a piece in the larger framework of the European policies for the reduction of waste and improvement of urban environmental conditions.
The reduction of noise is the first of these aspects and has a direct impact on citizens. The possibility of raising the reuse of crumb rubber to 100%, thus avoiding its incineration, has advantages in economic and environmental terms, as it reduces the emission of harmful substances in the atmosphere.

Economic issues

Although the current costs are still higher than traditional techniques, the advantages on a larger scale appear to be of significant interest. And if on one side it is feasible that a solid production chain based on waste reuse and recycle – with consequent employment opportunities – can established, the reduction of disposal costs generates advantages for the whole community, which can use those resources for works or actions that are directly aimed to the needs of the citizens.

Social issues

Pursuing better life quality in urban centres is a top priority for citizens and their Administrations. Noise pollution is an element of environmental considerations that has been greatly underestimated and the Italian regulation started to address it only 20 years ago, with the first framework Law approved in 1995 and integrated by the Piedmont Region in 2000 through a specific regulation.

As a result, the opportunity we face today is to provide new operational tools for reducing noise pollution and obtain sensible improvements of urban living conditions.

Communicating and showing that all materials can be reused appropriately and not only for demonstration purposes can generate a higher awareness of citizens and produce important changes in disposal techniques, achieving higher separated waste collection levels (the Metropolitan City of Turin currently separates 50% of waste, with consequent complications for the reuse of end-of-cycle products).

Public policies

In the overall complex waste management system, this project opens opportunities for public Administrations to be proactive agents of the entire waste reduction process through a gradual increase of recycled materials, not limited to regulatory and sanctioning functions.
A more central role of public Administrations in the use of materials derived from the recycling processes would ensure an effective governance of industrial waste reduction and reuse.

4. SECTION 3: Cost-benefit analysis

4.1 Definition of costs – The Regional price list

The general law on public works defines the working procedures for construction activities on the regional territory; the Regional Board has scheduled the definition and updating of a dedicated price list to which public and private operators should refer to.

In order to guarantee the quality of administrative activities while respecting the principles of participation, transparency, efficiency and effectiveness, since 1999 two protocols have been undersigned by the Piemonte Region, the Ministry of Infrastructures and Transport, the Regional Body for Public Works and all the other Institutions and Associations involved and that in the past participated in publishing the annual regional price list.

The main goal of the protocols is to promote, by means of a coordinated action, the satisfaction of the needs of all involved operators, with an emphasis placed on the adequacy of prices adopted for public works. Analyzed and listed costs refer to the regional price list (for the year of executive design) and therefore cost deviations are adherent to prices calculated on a yearly basis by the Region. Variations are not only due to inflation but also to the variable availability of raw materials on the Italian market.

4.2 Analysis of costs re-evaluated at 2015

After having identified the different road works carried out in the last 10 years in the territory of Settimo Torinese, the fist activity carried out was to highlight homogeneous pavement-related working activities and corresponding costs.

In the following, starting from identified costs, re-evaluated costs calculated according to ISTAT coefficients, are listed. Considered correction indexes derive from consumer prices for the entire collectivity (Nic), for families (Foi), prices of industrial production, construction costs for residential buildings, salaries.

The following tables show costs (per square meter) for pavement construction previously analyzed and re-evaluated at 2015 with the above described method.

VIA TORINO I LOT year 2002			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,55	1,255	€ 0,69
Wearing course 3 cm	€ 3,05	1,255	€ 3,83
TOTALE	**€ 3,60**		**€ 4,52**

VIA TORINO II LOT- year 2006			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,59	1,155	€ 0,68
Wearing course 3 cm	€ 3,26	1,155	€ 3,77
	€ 3,85		**€ 4,45**

ASSE SUD I STRALCIO - year 2006			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,63	1,155	€ 0,73
Wearing course 3 cm	€ 3,36	1,155	€ 3,88
	€ 3,99		**€ 4,61**

ASSE SUD I STRALCIO - year 2006			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,43	1,155	€ 0,50
Wearing course 3 cm	€ 3,36	1,155	€ 3,88
	€ 3,79		**€ 4,38**

CORSO AGNELLI year 2006			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,63	1,155	€ 0,73
Wearing course 3 cm	€ 3,36	1,155	€ 3,88
	€ 3,99		**€ 4,61**

BORGATA PARADISO year 2007			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,69	1,138	€ 0,79
Wearing course 4 cm	€ 4,65	1,138	€ 5,29
	€ 5,34		**€ 6,08**

VIA GIACOSA VIA RIO FRACASSO year 2007			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,69	1,138	€ 0,79
Wearing course 4 cm	€ 4,65	1,138	€ 5,29
	€ 5,34		**€ 6,08**

VIA CONSOLATA year 2008			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,69	1,106	€ 0,76
Wearing course 3 cm	€ 3,50	1,106	€ 3,87
	€ 4,19		**€ 4,63**

VIA SAN MAURO year 2008			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,46	1,106	€ 0,51
Wearing course 4 cm	€ 4,65	1,106	€ 5,14
	€ 5,11		**€ 5,65**

VIA VOLTA VIA PALESTRO year 2008			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,69	1,106	€ 0,76
Wearing course 3 cm	€ 3,50	1,106	€ 3,87
	€ 4,19		**€ 4,63**

VIA CASTIGLIONE VIA ARIOSTO year 2008			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,69	1,106	€ 0,76
Wearing course 3 cm	€ 3,50	1,106	€ 3,87
	€ 4,19		**€ 4,63**

VIALE PIAVE year 2008			
WORK	UNIT COST	COEFF ISTAT	COST Re-evaluated 2015
Bituminous emulsion	€ 0,55	1,106	€ 0,61
Wearing course 3 cm	€ 4,11	1,106	€ 4,55
	€ 4,66		**€ 5,15**

From the following table the unit cost for construction per square meter of pavement can be extracted (costs re-evaluated at 2015).

	YEAR	UNIT COST 2015
VIA TORINO I LOTTO	2002	€ 4,52
VIA TORINO II LOTTO	2006	€ 4,45
ASSE SUD I STRALCIO	2006	€ 4,61
ASSE SUD II STRALCIO	2006	€ 4,38
CORSO AGNELLI	2006	€ 4,61
BORGATA PARADISO	2007	€ 6,08
VIA GIACOSA - VIA RIO FRACASSO	2007	€ 6,08
VIA CONSOLATA	2008	€ 4,63
VIA SAN MAURO	2008	€ 5,65
VIA VOLTA - VIA PALESTRO	2008	€ 4,63
VIA CASTIGLIONE-VIA ARIOSTO	2008	€ 4,63
VIALE PIAVE	2008	€ 5,15
AVERAGE UNIT COST		**€ 4,95**

Costs for Via Brescia (with crumb rubber from ELTs, TYREC4LIFE project) do not derive from the Regional pricce list but from a specific pricce analysis of the products currently available on the market.

VIA BRESCIA (WITH CR FROM ELTs ANNO 2015	
WORK	UNIT COST
Sub-section I	
SAMI	€ 3,51
DENSE-GRADED 3 cm	€ 7,66
	€ 11,17
Sub-section II	
EMULSION	€ 1,17
GAP-GRADED 3 cm	€ 9,10
	€ 10,27

The difference in cost is apparent. However, a correct evaluation needs to be based on cost-benefit concepts.

4.3 Evaluation methods

The typical situation for cost-benefit analysis is that of a public Institution which has a limited available budget with the option of several projects and works.
The incisions which have to be taken by the Administration are two:

- Is the project admissible for funding?
- What is he ranking of the available projects/works?

The main decision criteria are:
• current net value VAN,
• internal return rate TIR
• benefit-cost ratio ABC

In this study the VAN criterion was adopted.

Starting from costs re-evaluated at 2015, VAN was calculated for reference sections of 6,000 square meters equivalent to 1 km of urban road (two ways, one lane per direction). Based on the experience of the Administration of the City of Settimo Torinese it was hypothesized that every 5 years 20% of pavements need to be subjected to maintenance and that after 15 years the wearing course has to be substituted. Given their high performance potential and durability, for pavements containing crumb rubber from ELTs it was assumed that no works would be necessary for 15 years.

MODEL
VAN CALCULATION

	B	C	D	E	F	G	H	I
	COSTS	**%**	**PRICE**	**QUANTITY**	**UNIT**	**TOTAL**	**I year**	**II year**
4	Cost				mq	=D4*E4	=G4	
5	register expenses	0,1				=C5*G4	=G5	
6	notary fees	0,01				=C6*G4	=G6	
7	technical costs	0,05				=C7*G31	=($G7*0,1)/3	=($G7*0,1)/3
8	Overheads	0,04				=C8*G31	=$G8/16	=$G8/16
9	marketing expenses	0,02				=$C9*G38	=$C9*H38	=$C9*I38
10	TOTAL					=SOMMA(G4:G9)	=SOMMA(H4:H9)	=SOMMA(I4:I9)
11	**INFRASTRUCTURE COSTS**							
12	Construction			=E25+E26+E27	mq	=(G25*0,0653)+(G26*0,05)+(G27*0,1)		
13	Secondary (residential)			=E25*3	mc	=D13*E13		
14	Secondary (Aspi)			=E26+E27	mq	=D14*E14		
15	TOTAL					=SOMMA(G12:G14)	=SOMMA(H12:H14)	=SOMMA(I12:I14)
16	**DEMOLITION COST**							
17	Structures concrete				mc	=D17*E17		
18	Masonry works				mc	=D18*E18		
19	sheds				mq	=D19*E19		
20	TOTAL					=G17+G18+G19	=H17+H18+H19	=I17+I18+I19
21	**CONSTRUCTION COSTS**							
22	Infrastructure network			=(E25+E26+E27)*3	mc	=D22*E22		
23	Sidewalks and streets				mq	=D23*E23		
24	ground level car parks				mq	=D24*E24		
25	Residential building			=#RIF!	mq	=D25*E25		
26	commercial building			=#RIF!	mq	=D26*E26		
27	Building for the tertiary			=#RIF!	mq	=D27*E27		
28	basement building			=E25/7	mq	=D28*E28		
29	underground parking			=(E25*3)/10	mq	=D29*E29		
30	Green				mq	=D30*E30		
31	TOTAL					=SOMMA(G22:G30)	=SOMMA(H22:H30)	=SOMMA(I22:I30)
32	**TOTAL COST**					=G10+G15+G20+G31	=H10+H15+H20+H31	=I10+I15+I20+I31
33								
34	**REVENUES (sales)**		**PRICE**	**QUANTITY**	**UNIT**	**TOTAL**	**I year**	**II year**
35	Residential building			=E25	mq	=D35*E35	=$G35*#RIF!	=$G35*#RIF!
36	Commercial building			=E26	mq	=D36*E36	=$G36*#RIF!	=$G36*#RIF!
37	Business buildilg			=E27	mq	=D37*E37	=$G37*#RIF!	=$G37*#RIF!
38	**TOTAL REVENUES**					=G35+G36+G37	=H35+H36+H37	=I35+I36+I37
39								
40	**FLOW STATEMENT**	**ANNUAL**				=G38-G32	=H38-H32	=I38-I32
41	**INTEREST**							=SE(H44>0;H44*C42;H44*C43)
42		0,027						
43								
44	**EXPOSURE**						=H40	=H44+I40+I41
45	**CASH FLOWS**						=H40+H41	=I40+I41
46								
47	**VAN (r = 10%)**					**=VAN(C48;H45:I45)**		
48	0,1	=((B48+1)^(1/4))-1						

VAN traditional pavement

INVESTMENT COSTS	%	PRICE	QUANTITY	U.M.	TOTAL PER YEAR	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year
works amount		€ 4,95	6.000	mq	€ 29.700,00	€ 29.700,00														€ 29.700,00
TOTAL					€ 29.700,00	€ 29.700,00	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ 29.700,00
TOTAL COST					€ 59.400,00	€ 29.700,00	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ 29.700,00

COSTS (operating)		PRICE	QUANTITY	U.M.	TOTAL PER YEAR	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year
ROUTINE MAINTENANCE (4 interventions per year)					€ -		€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
EXTRAORDINARY MAINTENANCE		€ 4,95	1.200	mq	€ 5.940,00					€ 5.940,00					€ 5.940,00					
TOTAL					€ 5.940,00															
TOTAL OPERATING COSTS					**€ 11.880,00**	**€ -**	**€ -**	**€ -**	**€ -**	**€ 5.940,00**	**€ -**	**€ -**	**€ -**	**€ -**	**€ 5.940,00**	**€ -**	**€ -**	**€ -**	**€ -**	**€ -**

REVENUES (OPERATING)		PRICE (€)	QUANTITY	U.M.	TOTAL PER YEAR	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year
					€ -		€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
TOTAL OPERATING REVENUES					€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
FLOW STATEMENT						-€ 29.700,00	€ -	€ -	€ -	-€ 5.940,00	€ -	€ -	€ -	€ -	-€ 5.940,00	€ -	€ -	€ -	€ -	-€ 29.700,00
INTEREST (interest charged by the Cassa Depositi e Prestiti)							-€ 801,90	-€ 823,55	-€ 845,79	-€ 868,62	-€ 892,08	-€ 1.076,54	-€ 1.105,61	-€ 1.135,46	-€ 1.166,12		€ -	€ -	€ -	€ -
2,70%																				
EXPOSURE						-€ 29.700,00	-€ 30.501,90	-€ 31.325,45	-€ 32.171,24	-€ 38.979,86	-€ 39.871,94	-€ 40.948,48	-€ 42.054,09	-€ 43.189,55	-€ 50.295,67					-€ 29.700,00
CASH FLOWS						-€ 29.700,00	-€ 801,90	-€ 823,55	-€ 845,79	-€ 6.808,62	-€ 892,08	-€ 1.076,54	-€ 1.105,61	-€ 1.135,46	-€ 7.106,12					-€ 29.700,00

VAN	**- 75.239,91**
1%	

VAN Pavement with CR from ELT – life-time 15 years

INVESTMENT COSTS	%	PRICE (€)	QUANTITÀ	U.M.	TOTALE	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year
works amount		10,27	6.000	mq	61.620,00	61.620,00														61.620,00
TOTAL					61.620,00	61.620,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	61.620,00
TOTAL COST					123.240,00	61.620,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	61.620,00

COSTS (OPERATING)		PREZZO (€)	QUANTITÀ	U.M.	TOTALE ANNUO	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year
ROUTINE MAINTENANCE (4 interventions per year)					0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
EXTRAORDINARY MAINTENANCE		10,27		mq	0,00					0,00					0,00					
TOTAL					0,00															
TOTAL OPERATING COSTS					**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

REVENUE (OPERATING)		PREZZO (€)	QUANTITÀ	U.M.	TOTALE ANNUO	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year
					0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL OPERATING REVENUES					0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

FLOW STATEMENT						-61.620,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-61.620,00
							-1.663,74	-1.708,66	-1.754,79	-1.802,17	-1.850,83	-1.900,81	-1.952,13	-2.004,83	-2.058,97		0,00	0,00	0,00	0,00
INTEREST (interest charged by the Cassa Depositi e Prestiti)																				
2,70%																				
EXPOSURE						-61.620,00	-63.283,74	-64.992,40	-66.747,20	-68.549,37	-70.400,20	-72.301,01	-74.253,14	-76.257,97	-78.316,94					-61.620,00
CASH FLOWS						-61.620,00	-1.663,74	-1.708,66	-1.754,79	-1.802,17	-1.850,83	-1.900,81	-1.952,13	-2.004,83	-2.058,97	0,00	0,00	0,00	0,00	-61.620,00

VAN	- 129.792,95
1%	

VAN Pavement with CR from ELT – life-time 20 years

INVESTMENT COSTS	%	PRICE (€)	QUANTITY	U.M.	TOTAL	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year	16st year	17st year	18st year	19st year	20st year
works amount		10,27	6.000	mq	61.620,00	61.620,00																			61.620,00
TOTAL					61.620,00	61.620,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	61.620,00
TOTAL COST					61.620,00	61.620,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	61.620,00

COSTS (OPERATING)		PREZZO (€)	QUANTITÀ	U.M.	TOTALE ANNUO	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year	16st year	17st year	18st year	19st year	20st year
ROUTINE MAINTENANCE (4 interventions per year)					0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
EXTRAORDINARY MAINTENANCE		10,27		mq	0,00					0,00					0,00										
TOTAL					0,00																				
TOTAL OPERATING COSTS					**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

REVENUE (OPERATING)		PREZZO (€)	QUANTITÀ	U.M.	TOTALE ANNUO	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year	16st year	17st year	18st year	19st year	20st year
					0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL OPERATING REVENUES					0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

FLOW STATEMENT						-61.620,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-61.620,00
							-1.663,74	-1.708,66	-1.754,79	-1.802,17	-1.850,83	-1.900,81	-1.952,13	-2.004,83	-2.058,97		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
INTEREST (interest charged by the Cassa Depositi e Prestiti)																									
2,70%																									
EXPOSURE						-61.620,00	-63.283,74	-64.992,40	-66.747,20	-68.549,37	-70.400,20	-72.301,01	-74.253,14	-76.257,97	-78.316,94					0,00	0,00	0,00	0,00	0,00	-61.620,00
CASH FLOWS						-61.620,00	-1.663,74	-1.708,66	-1.754,79	-1.802,17	-1.850,83	-1.900,81	-1.952,13	-2.004,83	-2.058,97	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-61.620,00

VAN	**-€ 127.216,92**
1%	

VAN Pavement with CR from ELT – life-time 20 years with 30% cost reduction

INVESTMENT COSTS	%	PRICE (€)	QUANTITY	U.M.	TOTAL	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year	16st year	17st year	18st year	19st year	20st year
works amount		7,15	6.000	mq	42.900,00	42.900,00																			42.900,00
TOTAL					42.900,00	42.900,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	42.900,00
TOTAL COST					42.900,00	42.900,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	42.900,00

COSTS (OPERATING)		PRICE (€)	QUANTITY	U.M.	TOTAL	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year	16st year	17st year	18st year	19st year	20st year
ROUTINE MAINTENANCE (4 interventions per year)					0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
EXTRAORDINARY MAINTENANCE		7,15		mq	0,00					0,00					0,00										
TOTAL					0,00																				
TOTAL OPERATING COSTS					**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

REVENUE (OPERATING)		PRICE (€)	QUANTITY	U.M.	TOTAL	1st year	2nd year	3rd year	4st year	5st year	6st year	7st year	8st year	9st year	10st year	11st year	12st year	13st year	14st year	15st year	16st year	17st year	18st year	19st year	20st year
					0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL OPERATING REVENUES					0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

FLOW STATEMENT						-42.900,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-42.900,00
							-1.158,30	-1.189,57	-1.221,69	-1.254,68	-1.288,55	-1.323,35	-1.359,08	-1.395,77	-1.433,46		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
INTEREST (interest charged by the Cassa Depositi e Prestiti)																									
2,70%																									
EXPOSURE						-42.900,00	-44.058,30	-45.247,87	-46.469,57	-47.724,25	-49.012,80	-50.336,15	-51.695,22	-53.090,99	-54.524,45					0,00	0,00	0,00	0,00	0,00	-42.900,00
CASH FLOWS						-42.900,00	-1.158,30	-1.189,57	-1.221,69	-1.254,68	-1.288,55	-1.323,35	-1.359,08	-1.395,77	-1.433,46	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-42.900,00

VAN	-€ 88.568,74
1%	

4.4 Parameters for evaluation

The above illustrated analyses have led to the determination of the indicators which should be employed for the evaluation of the true profitability of using pavements with crumb rubber from ELTs. These parameters can be grouped in two categories (environmental and economic).

Environmental parameters

1) Noise reduction

ARPA Veneto (Regional Agency for the Protection of Environment) carried out an estimate of traffic related noise by means of SEL. The model refers to a continuous level of weighted acoustic pressure evaluated on the daily exposure period (6.00-22.00) starting from traffic flows and from measured SEL values for categories of roads and vehicles. By measn of by-pass techniques SEL values were measured at the road edge and at 4 m from ground level. A synthesis of obtained values follows.

Road type	**Average SEL (dB)**	
	cars	**trucks**
ineterquartiere	77,3	83
quartiere	75,5	85
local	74,2	84,7

2) Accident reduction

One of the causes of accidents in the urban context is the state of pavements. Use of wearing course layers containing crumb rubber from ELTs shoud lead to a reduction of potholes, with the consequent reduction of accidents quantifiable by 1 and 6%.

Economic parameters

1) The main parameter is unit cost per square meter for construction (to which Administrations usually refer to).
2) The factor to consider is maintenance and its costs distributed in time.

VAN can be derived from such factors/costs and such a parameter can be referred to as the single parameter for economic evaluation.

5. Conclusions

This report addresses the evaluation of the project by trying to combine the strictly economic factors with a more qualitative evaluation based on SWOT analysis.
The adopted method combines different approaches highlighting useful elements for the evaluation of economic-financial feasibility of different projects in a clear and replicable way.
The characteristics of employed tools are those of homogeneity, automation and simplicity.
Two issues should be underline:

1) direct implementation of qualitative analysis with the possibility of considering direct and indirect effects deriving from investment costs (subdivided in four macro-categories);
2) use of available economic data which can be checked on the market and can be easily updated by Administrations.

Specific evaluation of environmental parameters associated to the TYREC4LIFE project will be carried out in the after-life of the project. True profitability is currently measurable based on economic factors. Based on the analyses performed it can be concluded that in order to be attractive on the market pavements containing crumb rubber from ELTs should be subjected to a 30% reduction of costs and guarantee a life-time of at least 15 years.

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