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# PROGRAM FOR URBAN PAVING BY THE GOVERNMENT OF THE ARGENTINEAN PROVINCE OF CHUBUT. A SUSTAINABLE MODEL WITH A GREAT SOCIAL IMPACT

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*Note: The notation in this paper is as follows: (.) for decimals and ( ) for thousands. Currencies are expressed as AR$ for Argentinean Pesos and US$ for US Dollars. Approximate exchange rate (2009-05) = 3,75 AR$ /1,0 US$.*

**Summary**

The Interlocking concrete block pavement (CBP) acquired a special importance in the province of Chubut (in the Argentinean Patagonia) as one of the best alternatives for paving in most of the urban municipalities and communes in the inner country. The benefits from high employment generation and low costs became evident with time. The involvement of the communities in the quarrying of the aggregate, the manufacture of the paver in nationally produced semi-automatic equipment, the movement of earth, and the construction of the pavement, made them the leading actors of their own progress and the improvement of their life quality.

This paper shows the wide spreading of CBP in Chubut, through the Provincial Urban Paving Program, and describes the experience for its implementation. In addition, it demonstrates the sustainability of this program, based on the synergy of the partnership between the Provincial Government, the Provincial Roads Administration, the municipalities, and the communes.

## 1. THE PROVINCE OF CHUBUT

The Province of Chubut is located in the Argentinean Patagonia. Its limits are: north with the Province of Rio Negro (parallel 42º S), south with the Province of Santa Cruz (parallel 46º S), west with the Republic of Chile, and east with the Argentine Sea (Atlantic Ocean).

Chubut is the third largest province of Argentina, with an area of 224 686 km$^2$, a population of 455 607 inhabitants, 26 municipalities, a Commission of Public Works, and 20 Communes. It has 47 towns, form the Commune of Altares, with 192 people, to the Municipality of Comodoro Rivadavia, with a population of 175 903.

The west of the province is on the Andean region, with cold and wet climate and significant snowfall in winter. It continues eastside with the extra-Andean region (plateau), with cold and dry climate, and goes down to the Coast, with cold weather in winter and hot weather in summer. Prevailing winds come from the west in all the regions (See Figure 1).

There is a large operation of natural resources in Chubut: oil, minerals, timber, livestock, fruit and vegetables, fish and seafood, and a variety of landscapes (national parks and natural reserves). Its main industries are aluminum, textiles, metalwork, fine fruits, and fishing, tourism and wing farms.

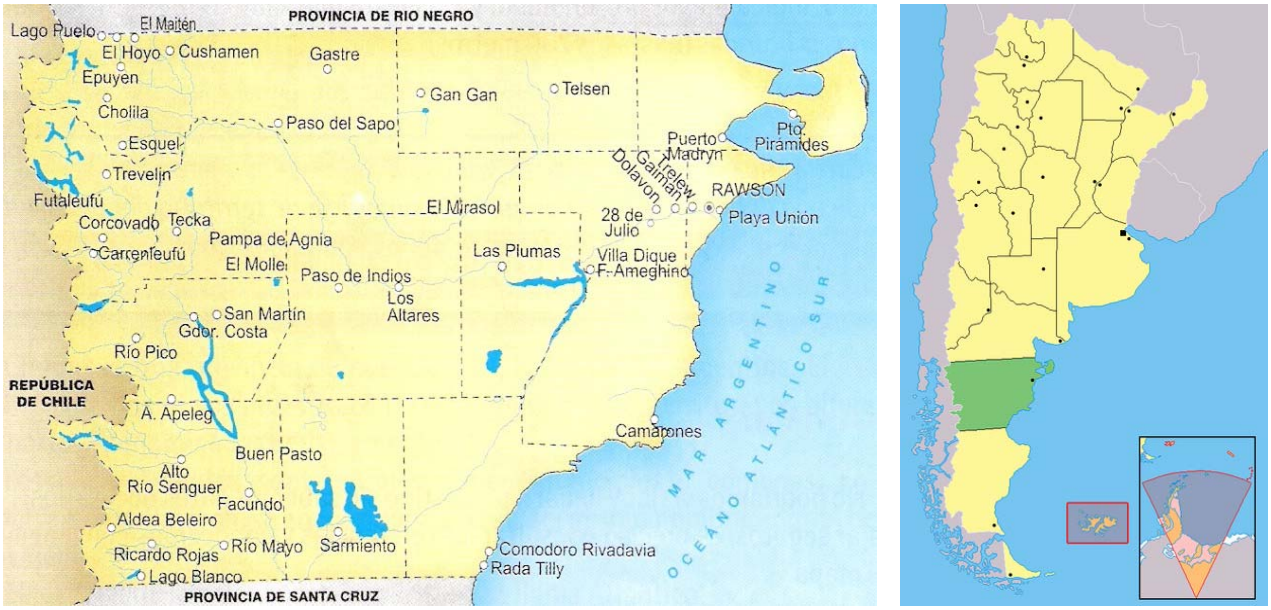



**Figure 1. Map of the Province of Chubut.**

## 2. PROGRAM FOR INFRASTRUCTURE BY THE PROVINCIAL GOVERNMENT

The Provincial Government, after its inauguration in 2003, began to define, adopt, and implement a state policy for the fulfillment of the basic needs of all settlements of Chubut, no matter their population. To reach this goal, the Provincial Government underwent the construction of a series of important public works and a significant amount of houses, schools, hospitals and gyms with shelters, infrastructure for the essential services (water, gas, sewer and electricity), curb-gullies and even ATMs, including the satellite Internet connection of even the smallest community.

The Administration also launched a plan for the reconstruction and paving of the national and provincial road network, as a joint venture with the National Government through the Provincial Road Administration and the National Road Administration. The plan included concrete or asphalt access roads to municipalities and communes. At that time, 72% of the 47 localities had not a single paved city block, although many were more than 100 years old, and the remaining 28% had a very little area of paved city blocks.

In parallel, the Provincial Government began to design its own program for urban pavements, using CBPs, initiated in December 2006 through the Provincial Road Administration.

Figure 2 shows the Community of Facundo, one of the smallest of the SW province, benefited by the programs for paving and for the accesses to communities.

## 3. PAVING FOR COMMUNITIES THROUGH CBP

The aim of the program is to pave all the streets in the inner urban locations of the Province of Chubut, in a six-year period. It will improve the quality of life of their residents, facilitate the mobility of pedestrians and vehicles, reduce the dust suspended in the air and lower the maintenance costs of the streets.

The idea of the program comes from in the need of the municipalities for street pavements with a more flexible and cheaper alternative than the traditional ones, and for the generation of employment inside their communities by training them in how to build the pavement. Employment

generation cannot easily be achieved, or in a large amount, through asphalt or concrete paving. In this way, the Government of the Province of Chubut, through the Provincial Road Administration, designed the Urban Paving Program. The municipalities welcomed this program as a way to fulfill the demand for paving and to improve the quality of life of the people, and made them the leading actors of the progress of their communities.



**Figure 2. View of the Facundo commune.**



**Figure 3. Typical crew in a community.**

This governmental program does not interfere but complement the private activity, and it is a way of making CBP popular in Chubut. Since much of the communities are in the mountainous central plateau, far from major cities, it is very difficult to provide them with the technology for concrete or asphalt paving, so CBP becomes their only alternative, with no need for big machinery but a lot of non-specialized labor.

In this region of Argentina, the climate is a key factor, since during wintertime, it is not possible to work in the open. That is why it is very important to have a paving system as CBP that can be built even under very low temperatures. Concrete pavers are manufactured and delivered with a cover to the job site, ready to use regardless of the weather conditions. The industrially produced pavers have a strict manufacturing control for the quality and dosage of materials, the curing process, and their dimensions, leading to a quality product.

The pavement projects in the communities go from 4 000 $m^2$ to 40 000 $m^2$. Being then so small, the Program decided to install only one factory, in a strategic area with respect to the provision of raw materials and the distribution of pavers. It allows to focus all the efforts of the producer to optimize the quality of the product by improving the equipment, the selection of materials, the general quality control, and the curing and testing methods of the pavers. This process was possible with the cooperation of experienced producers and the Argentine Association of Concrete Blocks (AABH).

The most remarkable advantages that influenced the Program with CBP are:

- The possibility to build one or two blocks in remote locations of the province at a cost far below the asphalt alternative
- A construction time of less than one month per block
- The possibility of paving the streets despite the inexistence of a complete, or recently built, network of public services.
- The easy and cost effective method of repair they gave, using local people.
- The adaptation to curves, steep slopes, irregular widths, and widths greater than 10 m or 12 m

- The improvement of the skid resistance of the pavement, for the safety of the vehicle when there is snow or ice on the pavement, and so on.

There was a major challenge "not to create a negative image in the municipalities during the construction of the pavement" which was offset by the Provincial Road Administration, responsible for managing the program.

## 4. SOCIAL ROLE

The PIAH acquired a special significance in the province of Chubut. The benefit of high employment generation and urban improvement became evident with time. Labor is hired in each municipality, and there is no need for specialized personnel and equipment from outside (Figure 3 shows a crew for CBP construction in the Municipality of Trevelin).

Self-construction by the users, can reduce costs, and allows CBP on a progressive basis according to the changing needs and opportunities of each municipality. The municipality becomes the contractor and is technically and economically responsible for the pavement.

Some important points to stress are the generation of pride within the community, the improvement in life quality, the income generation for the community and the improvement of their overall situation. CBP allows on-site training of labor, making it an attractive and valid option from the technical and economic perspectives, if among the purposes of the Program there are the generation of employment and the creation of local development.

## 5. DESCRIPTION OF THE COMPLETE PROGRAM

The success of the PPU in Chubut (See Figure 4) is based on the fact that it was designed and implemented by the Government of the Province, through the Provincial Road Administration, and the joint and responsible work with other governmental offices as the Provincial Executing Unit (UEP), the Provincial Institute of Housing (IPV), the Corporation for Improvement (CORFO), the Ministry of Infrastructure, the Planning and Public Services, and the staff of the municipalities and communes. There is also a major collaboration from the AABH, its members, private companies, and suppliers.

The Program has the force of action and organization of the Provincial Road Administration, whose trained staff and equipment are distributed throughout the province, added to the synergy of the joint work of the participants.

Two years after the program started, it still has some bugs on which the Provincial Road Administration works daily to correct. However, in the context in which it is being developed, the results are very good, the effects have been immediate, the streets changed substantially and the communities are solving one of their main shortcomings.

The Urban Paving Program (See Figure 4) has a very strong primary impact on the most expensive items of paving, since it is based on the production of pavers, the equipment for the movement of soils and the labor for installation. The municipality pays for the product at a cost between 18% and 20% of cost in the market (to be explained later), the movement of soils is done with the participation of the equipment from the municipality and the Provincial Road Administration, and the installation of pavers is made with unskilled labor from the community.

Table 1 list the steps of the program, how they were implemented, and those involved in them.

## 5.1 Production of aggregates

The aggregates used for the production of pavers come from a quarry owned by the Provincial Road Administration, 20 km far from the factory. This quarry is a glacifluvial deposit on a "morena de fondo", composed by gravel and sand of changing grading. The quarried material is passed through a 62.5 mm (2.5") grid and then by a 10 mm x 10 mm vibratory screen. The resulting aggregate meets the grading required for pavers. Tests are done regularly since the product can change according to the location of the hill where it is extraction from.

**Figure 4. Model for the Urban Pavement Program.**

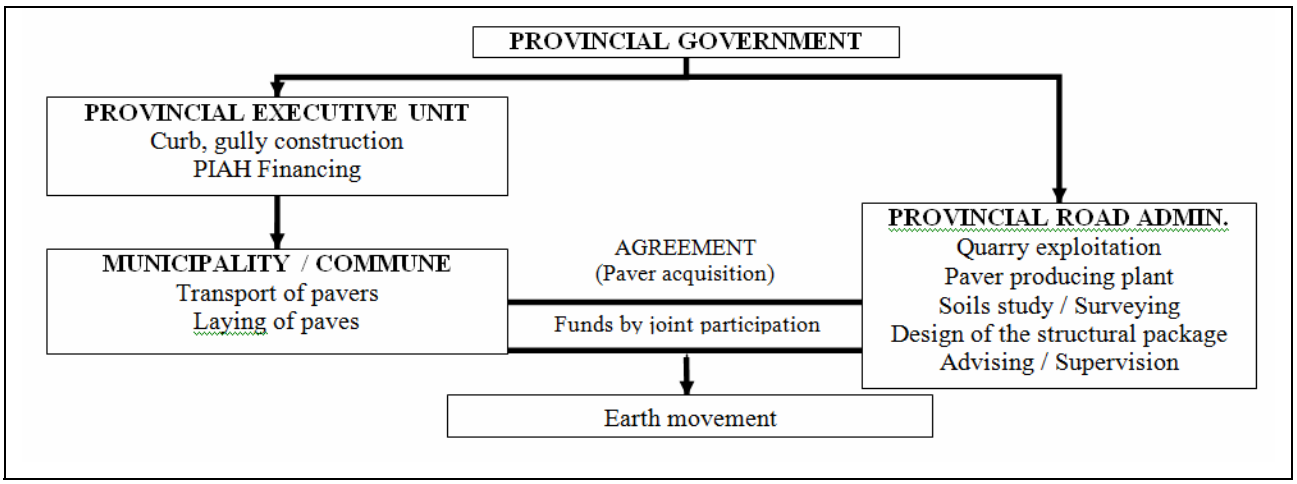



**Table 1. Steps of the program.**

| PAVER PRODUCTION | CONSTRUCTION OF THE BLOCK PAVEMENT |
|---|---|
| Aggregate production | Curb-gully / Project |
| Production of pavers | Soils study / Surveying |
| Laboratory | Structural design |
| Agreement | Soils movement |
| Transportation of pavers | Provision of granular base |
| | Installation of pavers |

Due to weather conditions, it is possible to quarry material only from September to April since from May to August, the water content of the material and snow, make it impossible to screen it.

The Provincial Road Administration has two refurbished screening equipments in the quarry, run with diesel fuel, a frontal loader (model 1977) with over 30 000 hours of use and a truck (model 1977) for moving materials within of the quarry. Those equipments are not suitable for routine roadwork. Additionally, they have been paid for in use and time. Figure 5 shows the quarry and equipment of the Road Administration. The transport of the material to the plant is carried out with trucks of the fleet of the Provincial Road Administration.

The staff working in the quarry is three drivers (full time) and a dispatcher, all of them employees of the Provincial Road Administration.

The final cost of the material on the plant is 25 AR$/$m^3$ (6.67 US$/$m^3$) (at an exchange rate of 3.75 AR$/1.0 US$, May 2009).



**Figure 5. Aggregate quarry of the AVP.**



**Figure 6. Semiautomatic equipment.**

## 5.2 Pavers plant

The plant for paver production opened November 2006, under the management of the Provincial Road Administration. It is on a 6 ha lot owned by CORFO, in Trevelin on Provincial Route 71 and Access Route to the Futaleufú Dam (NE Chubut). It is located in a strategic point for the distribution of the final product, as well as for the access to raw materials. It has a 1.200 $m^2$ warehouse and 150 $m^2$ of offices, canteen and toilets. It has a heating system in the area of equipment and the curing rooms that allows manufacturing throughout the year regardless the weather conditions in the mountain area.

An investment of AR$ 1 500 000 AR$ (US$ 400 000) was made for the conditioning of the building, the purchase of two semi-automatic, nationally produced equipments (see Figure 6) used for the production of pavers, an elevator, and the required equipment and tools to perform all type of repairs, welding, production of wooden pallets, etc. It also has a small, refurbished front loader, owned by the Provincial Road Administration. There are only two manufacturers of this or larger production capacity, semi-automatic equipment in Argentina.

The plant (See Figure 7) produces 220 000 Uni-Stone pavers, 80 mm thick per year, equivalent to 10 000 or 11 000 pavers per day. It is equivalent to 70 city blocks (a section of street or road about 100 m long x 10 m wide) or 70.000 $m^2$. Although this production does not seem very high compared to private producers in Argentina or in developed countries, it is enough to meet the objectives of the program of the government of the Province of Chubut. For a higher output it would be required to have another type of equipment and fewer workers, but one of the objectives of the government is the generation of jobs through this program, for this reason they purchased small, semi-automatic equipment.

The current production was compromised for five years, but due to increased demand and additional programs already emerging, the management began to acquire a new machine, in order to double the yearly production.

The plant has 26 workers (belonging to the Provincial Road Administration), divided into two shifts, starting at 7:00 pm and ending at 20:00. Initially they worked one shift with two machines simultaneously, but due to the significant amount of equipment failures, the efficiency was not the expected, thus the second shift was implemented with an additional foreman, achieving the intended goal (production is made in one machine and the second standby in case of a failure). One of the main drawbacks is that the plant is far from the cities where they can easily buy spare, so a failure of a major part can stop the equipment for a week or more.

The Provincial Government buys the cement, through the Provincial Road Administration. The yearly consumption is approximately 2 700 t, equivalent to 54 000 bags of cement, for a total of 1 500 000 AR$ (400 000 US$) annually. Since the equipments are semiautomatic, the provision is made of cement in 50 kg bags.

There is a deposit for aggregates with enough capacity for approximately 3 000 $m^3$, required for the operation during winter. It is necessary because during winter and storms, it is impossible to move the trucks between the quarry and the plant.

The annual budget for general maintenance and purchase of tools and plant reforms is AR$ 500 000 (US$ 133 333), and AR$ 1 000 000 (US$ 266 667) to pay for a year of staff salaries. Those amounts plus the cost of cement and aggregate, brings the cost of a paver to AR$ 1.05 (US$ 0.28) or 42 AR$/$m^2$ (US11.20 US$/$m^2$).

The AABH and many members of the association permanently advise the production on how to improve the quality. In addition, the factory has a Health and Safety Engineer, to ensure that all staff work safely.



**Figure 7. Paver factory in Trevelin.**



**Figure 8. Earth movement in Paso del Sapo.**

## 5.3 Laboratory

The plant is a laboratory itself for testing of aggregates (sand equivalent and grading) and pavers compression equipment). The periodic tests include the grading of the material produced in the quarry, and the one that is going to be used that same day in the mixers, in order to make the necessary adjustments.

For the determination of the strength, a daily sample of 10 to 20 pavers is taken randomly, to be tested for compression at 1, 7, 14, 21, 30 and 60 days. All tests follows the Argentina IRAM Standard 11656 *Adoquines de hormigón para pavimentos intertrabados*. A plant operator is trained to make the relevant tests (previously trained and supervised by professionals from the Central Laboratory of the Provincial Road Administration).

## 5.4 Commercial agreement

To acquire the pavers, the municipalities and communes have signed an agreement with the Provincial Road Administration for a certain number of “modules” per month, for a period of 36 months. The agreement is ratified by the Deliberative Council of each municipality and subsequently by the Government. Each “module” is equivalent to 4,000 pavers, so the total amount

of stones they purchase is "No. modules per month x 36 months x 4 000 pavers". The Provincial Road Administration anticipated a demand of 70 "modules", but they were sold in the first months of the program.

The cost of a "module" of pavers is AR$ 1 448 (US$ 386.13). The future price will have the same increment as the cement, defined by the Secretary of Infrastructure, Planning and Public Serveices, through the local chart of prices, Code 1.16.45 - National Cement, Comodoro 2 000, 50 kg bag. Therefore, the price paid by the Municipality for each paver is AR$ 0.36 (US$ 0.10) or 13.68 AR$/$m^2$ (3.84 US$/$m^2$), about 18% of the commercial value, or 34% of the cost.

The provincial government deducts the amount that corresponds to the monthly revenue for the plant from the payment made by the municipalities for the purchase of pavers and deposit it in a special account within the budget structure of the Provincial Road Administration. The funds are used to cover the costs required for the operation of the plant, supplies, wages, equipment rental, etc.

Currently there are 25 municipalities and communities inside the urban paving program. In addition to this program, in March 2009 was created a new program between the Nation and the Province, through which the Federal Government finances 68 city "blocks" distributed in 17 villages, four blocks each. The total for this program enter the province through the Provincial Institute of Housing (IPV), and the Provincial Road Administration is responsible for its implementation.

This implies that the 280 city "blocks" in execution, through the provincial program for Urban Pavement (paved along six years), 68 city "blocks" must be added from the Nation - Province program (to be paved within one year), resulting in a total of 348 CBP city "blocks", or the equivalent of 348 000 $m^2$.

## 5.5 Transportation of pavers

Each community has the responsibility for the transport of the of pavers from the plant in Trevelin in the PPU. It has an average cost of AR$ 12 000 (US$ 3.2) per city "block" (1 000 $m^2$) to anywhere in the province. The provincial government, through the Provincial Executing Unit, finances the costs of transport, earth movement and the labor for construction (See Figure 8). Additionally, they often use trucks with semi tow trucks or platform trucks owned by the Provincial Road Administration to transport the pallets of pavers, and with this, they help municipalities.

In the new "Region - Nation" program, the transportation is the entire responsibility of the Provincial Road Administration, which will buy two trucks with semi tow trucks, specially designed for moving the pavers.

## 5.6 Curb-gutter / Project

An important part of the program of CBP is that the provincial government, through the UEP, finances the construction of the curb-gutters in all the municipalities and communes of the Province, since the early days of the administration. This activity is the base for the beginning of the CBP.

## 5.7 Soil Study / Surveying

Professionals belonging to the central laboratory of the Provincial Road Administration, go all the communities taking soil samples for further testing of their grading and the support value. This work was done prior to any paving, and the report with the results was sent to the technical department in the heart of the Provincial Road Administration, for the structural design of the CBP.

The technicians responsible for the surveying department of the Provincial Road Administration level the streets, creating a project if necessary.

## 5.8 Structural design

With the report of laboratory, professionals from the technical department of the Provincial Road Administration do the structural calculation of the CBP by two methods: "Structural design of roads under the action of freezing - Eng Umberto Angelini and colleagues", and "Manual of Design and Construction - Chilean Institute of Cement and Concrete. They adopt the larger of both calculations. With the result, they write a report that is sent to the Municipality and the staff of the Provincial Road Administration which will supervise the movement of soils.

In many calculations they have added a film of nylon, 200 mμ thick, between the laid base and the bedding sand layer for the support of the pavers, to avoid this way, that moisture reaches the subgrade (taking into account that there hare towns where snow can be accumulated continuously on the streets for many days during three or four months).

## 5.9 Movement of soils and supply of aggregates

It is based on the report submitted by the technical department of the Provincial Road Administration. For the construction, they use the equipment provided by the Municipalities and the Provincial Road Administration (trucks, irrigator, loader, vibratory plate and levelers). In case equipment if not available from the UEP, it is rented.

The logistics of the work is done by trained personnel of the Provincial Road Administration, preparing the ground for two or four street "blocks", enabling in this way the start of the paving. Once finished, more city "blocks" are prepared.

In general, all communities have their own quarries within the municipalities, where material is removed for the construction of the base, and later or they do the same with the sand for laying the pavers. The determination of the quality of the quarry material is carried by the laboratory personnel of the Provincial Road Administration, by testing the corresponding samples.

Despite the fact that the movement of soil appears to be the most conflictive part of the construction of the pavement, due to the difficulty to get some equipment (taking into account that there are communities with fewer than 200 people in very remote places of the province), this is rapidly solved by the Provincial Road Administration. It has its equipment distributed all over the province and that the provincial government is equipped with trucks and loaders to all communities.

The estimated cost of the movement of soils and the provision of aggregates is 29,0 AR$/$m^2$ (7,73 US$/$m^2$).

## 5.10 Concrete block installation

This is a key point, and it produces the greatest social impact across the province. To implement the laying of the pavers, municipalities create crews of six to people, men and women, generally non-trained, unemployed or with no permanent job. Crews are managed by supervisors or staff of public works of the municipalities. The Provincial Road Administration prepared a manual with all the details and instructions for proper laying of pavers, as well as with the details for maintenance and possible causes of failure. This manual is given to all municipalities before the beginning of the work.

In addition, the Provincial Road Administration has two laying and instructors officials, who began the paving in all communities, instructing the people. Usually they stay for a week or 10 days in

each location, laying pavers and conveying the lessons learned from the beginning of the program. After that point, the communities continue alone with the laying. However, when encounter any difficulty as curves, steep slopes, irregular widths, etc., those officials come back to solve the problem.

The municipalities pay the wages for the labor in different ways, with costs from 10.0 AR$/m$^2$ to 20.0 AR$/m$^2$. This cost is paid the Province through the UEP.

In Figures 9 to 12 there are streets in the municipalities of Puerto Trevelin and Port Pyramids respectively, before and after paving.



**Figure 9. A street in Trevelin, before.**



**Figure 10. A street in Trevelin, now.**



**Figure 11. A street in Puerto Pyramids, before.**



**Figure 12. A street in Port Pyramids, now.**

## 6. COST OF PAVING

Table 2 shows the costs involved in the Provincial Program of Urban Pavement in the Province of Chubut. These figures were determined through a detailed costing.

## 7. CONCLUSIONS

The Urban Paving Program using concrete pavers in the province of Chubut is a sustainable program because it was designed by the Provincial Government and undertaken with a firm political

decision for it to run. The Provincial Road Administration was appointed as the primary responsible for the Program, in order to accomplish it, and worked with other Public Agencies, Municipalities, Communes and other participants, to make possible its implementation.

**Table 2. Costs involved in the Program.**

| ITEM | DESCRIPTION | AR$/m$^2$ | US$/m$^2$ |
|---|---|---|---|
| 1 | Production of pavers, Uni-stone (80 mm) | 42.00 | 11.26 |
| 2 | Surface soil removal (300 mm) | 10.78 | 2.89 |
| 3 | Leveling and compaction of the subgrade | 5.96 | 1.60 |
| 4 | Granular base (200 mm) | 12.37 | 3.32 |
| 5 | Transport of pavers | 11.25 | 3.02 |
| 6 | Laying of pavers (sand included) | 16.11 | 4.32 |
| | **TOTAL** | **98.47** | **26.40** |

This paper presented how this Program is actually working in this province, in order for the rest of the Argentine provinces and other locations abroad could adopt and implement it (making the previous improvements or modifications required by each location), due to the highly positive social impact caused on the communities.

## 8. ACKNOWLEDGMENTS

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