

Construction Yards in an Autarchic “Company Town”

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In all erecting yards people are restlessly working: by tens, by hundreds, thousands of thousands masons, carpenters, diggers and hodmen are building up the black outlines of the town that didn't exist before. Every day a wall is one meter higher, on some houses the red tiles are already being aligned, the recent cuts for the straight stretches of the new roads are already visible. People walk through heaps of materials, wood stacks, dislodged earth slush, cement sack piles badly guarded under corrugated irons, through groping lorries and jerking tracks on which little wagons run and sometimes run off the rails.

(Tonini 1943, p.12)



Figure 1. Carbonia original plan, 1937 (ACV)

In 1935, as a consequence of the invasion of Ethiopia, Italy was subject to international sanctions and the fascist government was constrained to find within its own territory those energetic resources it required, not only for the normal administration of civic life and industry, but also for its impending war programs. It is exactly within these restraints that the 'rediscovery' of Sardinian and Istrian coal commences (the coal seams were in fact already known, but until that time scarcely

used) with the sudden establishment of the *Azienda Carboni Italiani* (*Italian Coal Concern, A.Ca.I.*), a government controlled body which was to oversee the coordination and the development of mining activity, and the subsequent foundation of supporting workers towns.

The most considerable case, for its size as much as for the complexity of programme, is the new town of Carbonia. As the main urban centre of the mining area of south-western Sardinian, the region named Sulcis, it was first, in 1937, projected as a town for 12.000 inhabitants, built in only 300 days and inaugurated on December 18th 1938 in the presence of Mussolini. It later underwent further and intense programmes of enlargement, which were interrupted only by the outbreak of World War Two.

Besides being a relevant example of town planning and architecture of the twentieth century, it also represents an extraordinary building experience, which sets up and tests a store of techniques and building systems, that succeeded in reconciling the difficulties and urgency of the political and economic condition of the Nation, and the distance of the site from the various production centres, with the search for a language, that, in spite of all, finds its own, peculiar expression of modernity and is able to stand comparison with the national style of the time.

THE ORGANIZATION OF THE CONSTRUCTION SITE OF CARBONIA

A building site doesn't represent a comfortable situation in itself, and it becomes even more difficult if it's not a single building but a whole town that has to rise out of the dust in few months. That's exactly what happened in Carbonia. In a sparsely populated area, almost completely devoid of road networks the ordinary difficulties become much harder. The country around offered only masonry stone; all the rest had to be imported from far away: cement, iron, bricks, technologies and... men. So, first of all, there was the obvious necessity of planning the street and railway routes and equipping the adjoining harbour. At the same time the hoisting shafts were made deeper and the necessary structures of support installed. Among those, the first and most important is the village where the labour force will live. At first a rough hut village rose to lodge the first miners and building workers; slowly the 'wooden' Carbonia is replaced by the 'stone' Carbonia. The yard was *hard* and traditional in its materials and building techniques, modern and *Tailored* in management and production.

A great number of workers were in the service of more than a dozen building contractors; because of their large numbers and their poor background, episodes of disorder and social tension were not unusual, due to the pioneering conditions of the enterprise and the conflicts between contractors and workers. The echo of the difficulties regarding the construction work reaches even the management of the A.Ca.I.; a minute of a meeting of the board of directors reads:

Before ending his long statement, the President finds it dutiful to inform the Council about the state of the erecting works in Carbonia and about the difficulties that have

arisen from exceptional circumstances that he wants to specify. For the contracts of Carbonia, he says, the tender being ready and officiously submitted to the opinion of the Civil Engineers of Cagliari, the auctions for the single sites were arranged in proper time, realizing a fall from 14 to 10%. [...] The situation for the execution of such an imposing work has rapidly revealed itself as very difficult because of the general increase in prices on the market, the rise of the transport rates, the congestion of the port of S.Antioco and the ordinances of the Corporative Inspectorate (hutments and general conditions of the labour forces). Essentially, the environmental conditions and the difficulties with supplies, together with the scarcity of qualified labour forces in a zone that is saturated with work, have brought the building contractors into a situation engendered by unforeseeable and serious incidental contingencies so that the execution of the works has become negative for everyone. [...] It was also necessary to consider that the terms for the completion of Carbonia had to be absolutely respected, in respect of the precise order given by the Chief as to the necessity and urgency, which could not be disregarded, of giving the workers places to live in.

(ACS, MIC, DGM, Fasc. 1142)



Figure 2. Carbonia aerial view, 1938 (ASCC)

The applications (for payment) by the contracting firms confirm the enormous difficulties in the management of the works together with a lack of revenue receipts:

With the first application the firm asks for a 20% higher reward on the amount of the executed works on or before December 18th 1938 (inauguration of the town). The arguments given by the firm consist in the condition of particular discomfort in which all

the builders who had first arrived in Carbonia found themselves, due to many adverse circumstances. Among those, the following ones are particularly important: the nearly absolute lack of practicable roads; the obstruction of the harbour of S.Antioco, which was inadequate to satisfy all the new demands and had been caught in the middle of new works for its enlargement; the deficiency of the conveyance systems in general and of motor transport in particular; the shortage and qualitative deficiency of the labour forces: a scarcity that became even worse during the critical work, as a growing number of firms increased the search for workers; the lack of means offered by the environment, which is destitute of all required materials except the *trachytic* stone that was extracted from the quarries in quantities that could not keep pace with the growing needs of the masons yard; finally, the distance of Carbonia from the material production and distribution centres represented a great difficulty for all the constructors, especially during the first year.

(AIACP, C. 18)

Contrary to the official publications of the period, which all report epic descriptions of the project, with vigorous workers and intrepid engineers, only one text (Tonini 1943), from some aspects not much more than a *feuilleton*, shows the situation from a different point of view. The author is one of the contractors involved in the construction of Carbonia and he describes – from his own point of view, the difficulties, during the first months, with the installation and the management of the construction site, the hard life that all people, from the engineers to the workers, had to bear, the economical failures and even the suicides of some contractors. The tenor of the report is emphasised by the pride of having taken part in such an epoch-making event as the foundation of a new town, however, it does not hide the harshness of the situation, nor does it spare hard criticism towards the *high places*. Indeed, Tonini exposes how the firms were kept in dark about the worst aspects of the real working conditions, often making the estimates and offers, presented for the tenders, unreliable. Setting aside some fictional anecdotes, the rest seems to be the fruit of a personal experience and the atmosphere that comes out of the account is confirmed by the confidential documents of the prefecture (e.g. ACS, MIC, DGM, Fasc. 1146) and of Mussolini's secretariat (e.g. ACS, SPD, CO, Fasc. 501.134). The difficulties in the management of the labour forces are proved by the attention given to avoid imbalances between construction works and mining activities. The contractors are instructed, by a relevant specification item, not to employ labour forces who have been working for the Mining Company after a certain date, so as to avoid the miners leaving their jobs with the prospect of better working conditions in the field of construction. Moreover, the progress of the expansion of the town is regulated, beside the well-known reasons of the growth in productivity, but also by the necessity of opportunely deferring the execution of the works to avoid a surplus of unemployed labour that could cause social tensions in an already risky environment. To have a general idea of how many workers were employed in the yard, suffice it to say that, when Mussolini, during the inauguration of the town, promised the workers a reward of 100 Lire for each one, the amount of the distributed money reached at least 1 395 100 Lire (ACS, SPD, CO, Fasc. 190.692), which is equivalent to almost 14 000 workers employed on groundworks (Delogo 1988).

The list of those who are employed by the building contractors, drawn up by Vitale Piga (ACS, SPD, CO, Fasc. 190.692) as Secretary of the Fascist Industrial Workers Union, is close to 4 000 and Delogu talks about a turnover in the yard, during the whole working period, of at least 20 000 workers.

The frenzied pace and the hardness of the work are described very well in a passage from Tonini's report:

The town keeps on growing. Thousands and thousands of tonnes of cement, thousands and thousands more cubic metres of stone and sand. Lorries that cover many kilometres, like ants, with a continuous coming and going. They roll along night and day because the town needs a huge quantity of materials to grow. Nearly under their wheels, ranks of workers build the roads: in place of the old uneven and winding tracks some road-beds already draw straighter courses. Carpenters, engineers, masters become more and more exacting, every day they ask for more, because the end date is coming nearer, when the town will have to be ready and have its finished look. Thousands of mattocks go up and down, all day, brandished by burned, bronze arms. Shirt-sleeved boys run up and down the gangway-ladders all day, carrying containers full of lime and baskets with stones on their shoulders. The masons quickly fix one stone near the other, one brick near the other and big laying trowels with mortar bind the wall. From one week to the next, a house that consisted only in its foundation is suddenly covered with a roof. Everyone is feverish. Every now and then, a quarrel breaks out, people come to blows. Those who have an even ramshackle lorry get rich, because all the yards are hungry for stone and pay without too many controls on the regularity of every step. Those who open a shanty using it to sell bad wine, fill their cash desks with money. In the evening everyone's dead tired and smelling of sweat. In the shanties, in the temporary rooms hangs a terrible sultriness. The sleep of many is heavy but often broken. One says: "This is hard labour, but, Good Lord!, this time I'll make money..."

(Tonini, 1943 p205)

The management and the ownership of the whole system were in the same hands: the Italian Coal Concern (A.Ca.I.) managed the mines and owned all the industrial and civil structures. Carbonia is, in every respect, a *one company town* that is completely concentrated on only one productive system. The highly centralized hierarchical control had a positive effect on the organic management of the whole system, and of the construction which, therefore, shows constant and coherent characteristics. In November 1937 the Fascist Institute for the Council Houses of the A.Ca.I. was established to unify, under a single management, the real estate of the Company and optimize their use and enlargement (ACS, MIC, DGM, Fasc. 1146). The Institute supervises all the building yards with an efficient team of chief resident engineers who controlled and integrated the execution, regulating techniques, materials and constructive parts and operating a small prefabrication *in loco*

of elements produced in limited series. This is the case, both with public buildings with prefabricated ceiling beams, roof trusses and mouldings of artificial stone and, with the construction of dwellings, in which the individual elements are combined with standardized elements for the eaves mouldings, casings, balustrades, sills, etc... This early standardization process is moved by a rational and productive spur, aiming at increasing the output of the yard, despite the use of scarcely developed techniques and local materials.



Figure 3. Aerial view of the building site with tipping wagons, groundworks and just finished houses, 1939 (AEM)

The rate of industrialization, on the other hand, was very low: the historic photos show images in which the human component is definitely predominant compared to the mechanical one, in accordance with what has already been said about the techniques that were used in the yards. The few machines come from the mining industry, for example, the many *decauville* skip cars used to carry the stones, extracted from the neighbouring quarries, to the town and to transport earth and other materials from one area to another. In the yard there were concrete mixers but the cast was handmade, with the help of containers, used to lift the concrete. Materials are mainly transported on carts with animal-traction (oxen or horses, according to the financial records, (AIACP)) and, as an exception, on motor vehicles. The very bad condition of the roads, which were often only dirt roads, made traditional animal drawn means of transport preferable, all the more as, after 1939, the government proceeded to the call-up of all lorries and introduced rationing of fuel and tyres due to the imminent war. In that same year the mine was militarized and exempted from the mobilizations

as it represented a strategic resource for war activities. Nevertheless as often happened, later on, men were taken away by mistake – causing great damage to the mining and building activity – and having gone, it was very difficult to get them back to work.



Figure 4. Building progress diagram of Cortoghiana, Carbonia suburb, from the Council Houses Fascist Institute of the A.Ca.I., 1942 (Ist. Fascista per le Case Popolari dell' A.Ca.I., AIACP)



Figure 5. Historical film frames with groundmen working, 1940 (AIL)

The local trachytic stone, the main building material used in Carbonia, was extracted from several quarries that are very near the town, at convenient distances that meant that carriage to the site was economical. The quarrying activity was managed directly by the Mining Company, which sometimes employed piece-workers. The stone was broken out with explosives and then free-hand worked to obtain various semi-finished sizes for different uses. The best beds and veins supplied the material used for ashlar faced walls, whilst the second-rate material was used for interior or plastered and rendered masonry, however there is a fairly good uniformity in the general properties of the stone. In the supply of stone there were the same difficulties that generally troubled all the building activities in the yard, the contractors sometimes tried to influence activity, particularly with regard to price and distribution in a manner which suited themselves only, so that the management of works had to intervene and mediate for the correct distribution of the material.

In the construction yard of Carbonia all the terracing works and other earthworks were done by hand, with shovel and mattock, and the removed earth was carried away on skip cars. Formwork and scaffolds were made exclusively of wood, only in the post-war period (1957), at one of the *INA Casa Plan* sites, was metal scaffold made of *Innocenti* tube introduced in; the experimental nature of its use proved by the fact that it was employed only on one building, whilst the others, which are visible in the same historic photographs, still have wooden scaffolds, like those used during the first phase of building works at Carbonia.

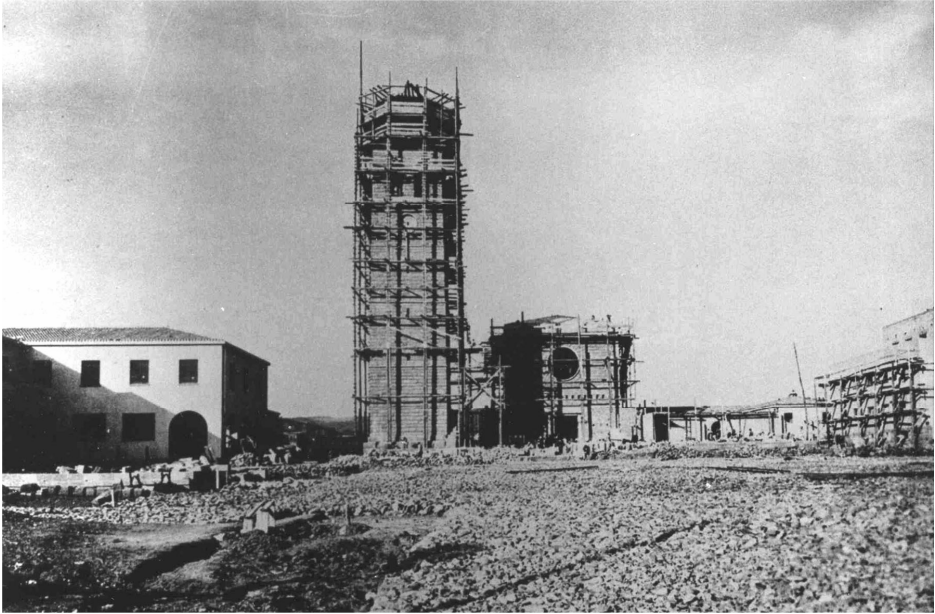


Figure 6. Historical view of the wood erecting scaffold for the S. Ponziano church and its belfry, 1938 (ASCC)



Figure 7. Historical film frames showing the Serbariu mining equipment 1940 (AIL)

We find the same contrast in observing the materials used in the two fields: almost exclusively stone, there was very little iron and only a sparing use of reinforced concrete in the urban buildings; whereas in the mining operation iron was the predominant element. The pit frames are outlined on the landscape with their rolled metal sections and reinforced concrete is used without any impediment, not only for the wall frames but also for whole structures such as the shower-room: a single, broad semicircular vault made integrally of reinforced concrete.



Figure 8. Shower and dressing hall in Serbariu mine site: a whole reinforced concrete barrel vault (AEM)

TECHNOLOGIES AND MATERIALS

One of the main difficulties that slowed down and troubled the progress of Carbonia's yards was the necessity of importing almost all materials for the construction work and for the finishes, from the peninsula, except, of course, for the local stone supplies. On top of that there was the poor training of the labour, for whom the construction yard was the first and easiest employment on their arrival in town: the workers were often farm labourers who know nearly nothing about construction and had, at most, some familiarity with hand working of stone; the construction firms needed to have an internal structure of experts and foremen in order to instruct and guide the workers. The chief resident engineers of the A.Ca.I. also took part in this training work, they follow the whole progress of the yards with a particular attention for the preparation and the casting of the concrete for the structures.

The mines of Carbonia were very soon militarized and designated as essential industry for war purposes, obtaining therefore a series of dispensations by 'autarchic' direction. The situation

regarding ferrous materials in the yard was indeed extremely complex. The allocations were scarce and underwent unforeseeable fluctuations, due to difficulties in naval transport and to the fact that all supplies of iron, and other metals, came from non-Sardinian production centres. All the allocations had to be previously approved by the General Commission for War Manufacturing (Co.Ge.Fa.G.) that established, each time, priorities, which led sometimes to paradoxical situations, there was a scarcity of coal, but the iron needed to provide it was often held up.

Ferrous products for Carbonia. [...] I assure that, in spite of the difficulties that, at the moment, hinder the metallurgic production because of the well-known shortage of coal and the non-arrival of scrap from abroad (caused by the sudden requisition of steamships for urgent coal transport), this Commission will do its best, depending on the supplies, to meet the requirements of the town of Carbonia.

(ACS, MIC, DGM Fasc. 1146)

The strategic importance of Carbonia for the national economy as for pre-war preparations was undoubted but, in spite of this, it often happened that construction work was interrupted or suspended because of the lack of reinforcement bars for reinforced concrete and lead pipe for hydraulic and plumbing works.

There were also similar difficulties in the importation and distribution of cement for mortars and concrete and even a scarcity of mixing water; nevertheless it was not unusual to find applications of reinforced concrete that were seemingly unnecessary. This is probably attributable to considerations of opportunity leading to certain choices prevailing on the saving of iron and cement *tout court*, in favour of the practicalities and increased speed of the construction work, which were at the same time necessary for the acceleration of mining activity and in this case, also due to factors related, indirectly, to autarchy. In general, on a national scale, beyond a sometimes demagogic and propagandistic use of the alleged energetic self-sufficiency of the nation, laws anyway were provided for the possibility of obvious and necessary dispensations for public works of great importance for the nation, among which Carbonia is certainly counted by right.

To a lesser extent, but no less significant, this same logic regulated the use of wood, a rare and *precious* material, included among those which were *branded* by the autarchy as imported goods. In the construction processes, wood was used to make scaffolds, rail sleepers, yard tracks and, most of all, formwork. Precisely for this reason the use of wooden-structured roof-trusses (used, in the urban centre, in very few buildings) was extremely limited, on the contrary, a sizeable proportion of the roofing elements of public buildings consisted of mass-produced reticular roof trusses made of reinforced concrete with formworks that was reused many times. For the same reasons of rationalization and limitation of the formworks, the intermediate floors were, nearly always, made of joists that were prefabricated inside the yard (like *SAP* or *REX* floor patents) and are much easier to install, needing at the most a dividing support and not an onerous unbroken boarding. In spite of

all this, wood still remained the most *autarchically* economical material, obviously an alternative to metal, for realizing internal and external frames, screens, garden fences and balustrades which all present the same scheme of interwoven laths and are one of the characteristic features of almost all public and residential buildings of Carbonia. Inserted in most of the apertures there are handling and opening mechanisms in *anticorodal*, the most important autarchic aluminium alloy which met with great success in the Italian architecture of the period.



Figure 9. Historical advertisements for *autarchic* materials: “Anticorodal” and “Cementite”

The superficial finishes and the realization of the floors were made with special care; in both cases national freestones are largely used. Italian marble, especially the Apuanian variety, was widely present in Carbonia – also if, unfortunately, surviving only in part - it satisfied both the needs of extreme resistance and decorum required by public buildings.

The supplies of marble came almost entirely, from the firm “Soc. Generale Marmi e Pietre d’Italia” (General Society of Italian Marble and Stones) that ass linked up with the important *Montecatini* chemical group. It was placed, in form of large slabs on the walls or, in smaller sizes, on the floors, making use of, in the best way, the decorative effect that results from the book-matched disposition of the natural veining and from the different colourings. In some floors under the arcades and, more rarely, in internal spaces we find examples of mosaic flooring sections, *alla veneziana*, that are still present and perfectly kept. Descending the scale of prestige of the buildings, we find grès floors or small-hexagon floors made of coloured cement, while, where there were particular hygienic and comfort needs, linoleum is the employed material, for the walls as well as for the floors.

All the wall surfaces were finished with cement lime mortar plaster, covered, in external spaces, with a *Terranova* plaster applied by spraying. The yard documents, if not specifying the provenance of the plaster, describe its chromatic shade very precisely, referring in particular to the characteristics of the public buildings and their colouration with white and red-pigment paste. The façades are further enriched by the use of artificial stone cornices characterized by a simple and essential shape, and cast-in-place or produced *in loco* with a mixture of concrete, rose pigments and trachyte grit, lightly reinforced and worked, after curing, with a chipping-hammer.

The pitched roofs were made with a double tile mantle; the horizontal ones were superficially finished with a quarry tile floor, above a layer of hot cast asphalt and an insulating base of *cellulite*, a particular mixture of concrete and soap that produces bubbles during the production process with the consequent isolating and lightening effect (Griffini 1934).

THE USE OF REINFORCED CONCRETE

Reinforced concrete represents the natural complement of masonry structures made of local trachyte, on which it is inserted in the shape of kerbs, architraves, arcades, covering structures and hollow block floors. If, as far as the linear elements are concerned, there are no special construction peculiarities, observation of the photographs of the yard, shows that the serial arcades were actually made entirely of reinforced concrete, hollowed out of the arches' outlines in order to reduce the natural drift. A further level of complexity was introduced by the reticular structures that formed the pitched roofs. These are roof trusses that are cast-in-place and hoisted on their bases after curing. They are employed in all the buildings of the urban centre, except for the post office and the townhall which, instead, have wooden frames and are directly drawn from the contemporary industrial buildings of the neighbouring mine of Serbariu. The prefabrication process, even if it introduces, in some cases, a series of effective advantages, that's to say when the elements are the same and duplicated, is much less convenient as the work standardization and acceleration are concerned, such as in the case of the variable-span coverings at, for instance, the *Cine-Theatre* building, in which each element is different from the other. For the roof trusses, there are many and detailed building plans of the reinforcement and general structure of the elements in the archives.

As already mentioned, the not so rare use of reinforced concrete seems to indicate a sort of contradiction, if we look at it with regard to the extreme difficulties concerning supplies and the inexperience of the labour force; but, most of all, it transgresses to the autarchic laws regarding the saving of metal materials towards which, instead, very *lay* and pragmatic ways were adopted. But, as already said, the resistance offered against the use of reinforced concrete was mainly caused by problems relating to the supply and availability of its main components. While the aggregates were easily available from the local quarries for the larger size particles, and integrated with *sand of Fontanamare* (a neighbouring beach) - as precisely ordered by the job specification - for the more minute particles, iron and cement continue to be components that are mostly in short supply.

The management and the distribution of the reinforcement bars in the yards of Carbonia were oriented to the best possible utilization of materials that were often very scarce and subject to fluctuations, to such an extent that the building constructors resorted to loans and advances granted by the Institute for Council Estates whilst they waited for the arrival of the ordered supplies. The works management often intervened to organize the best possible distribution of iron supplies among the various active yards, to avoid an excessive slowdown of some works to the advantage of others. The DL (works management), for example, sent a note to the Institute, asking for the go-ahead to lend the firm 'Tronci', working on the school site, some iron, "while we wait for the availability of the 45 tons of rods allotted, after having filed a proper application"; material which it resolutely asks to be returned as soon as it becomes available (AIACP, C. 18).

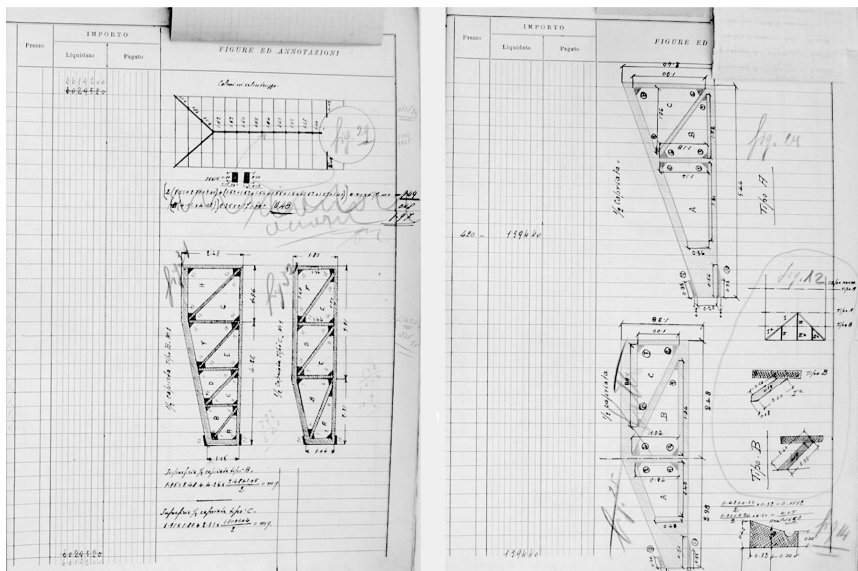


Figure 10. Drawing of the reinforced concrete trusses from the dimension book of the church and of the recreational club (AIACP)

The mainly craft-natured work of the yard limited the experimentation on autarchic materials to very few and specific cases concerning almost exclusively superficial finishes or accessory elements. The only *structural* exception are represented by the use of 'Rex' and 'Sap' floors that replaced and integrated the use of masonry-structured, depressed vaults. The two patents belong to those that were officially recommended, in 1936, for works financed with grant-aid, by the Department of Public Works, since they were considered the optimal solution in order to combine structural resistance and the saving of iron. Both systems are characterized by being made of prefabricated reinforced brick beams that are cast-in-place. They consist of brick blocks provided with special grooves in which thin 5-8 mm dia. bars are placed rather near one to another and then pointed with cement mortar.

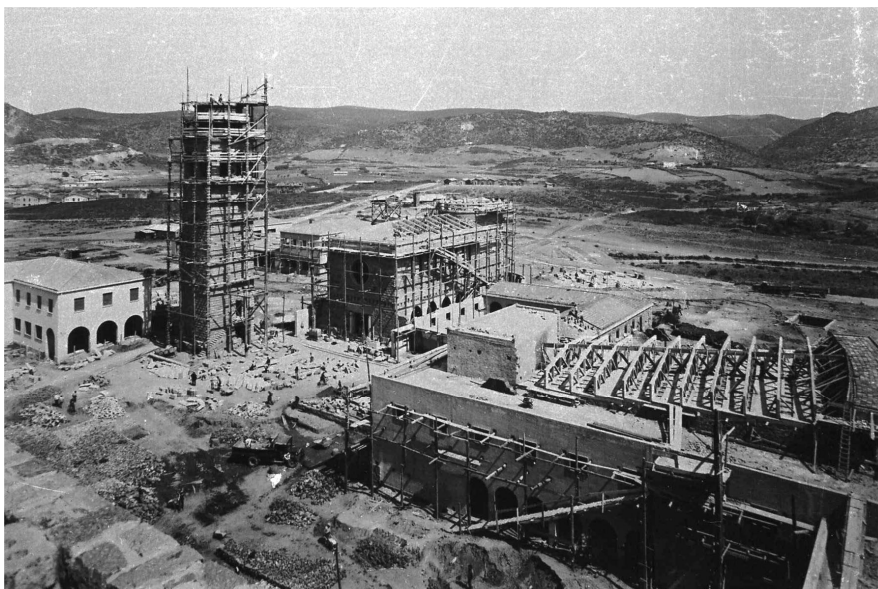


Figure 11. Urban centre historical view showing some reinforced concrete trusses in the roof of the theatre and of the church (ASCC)

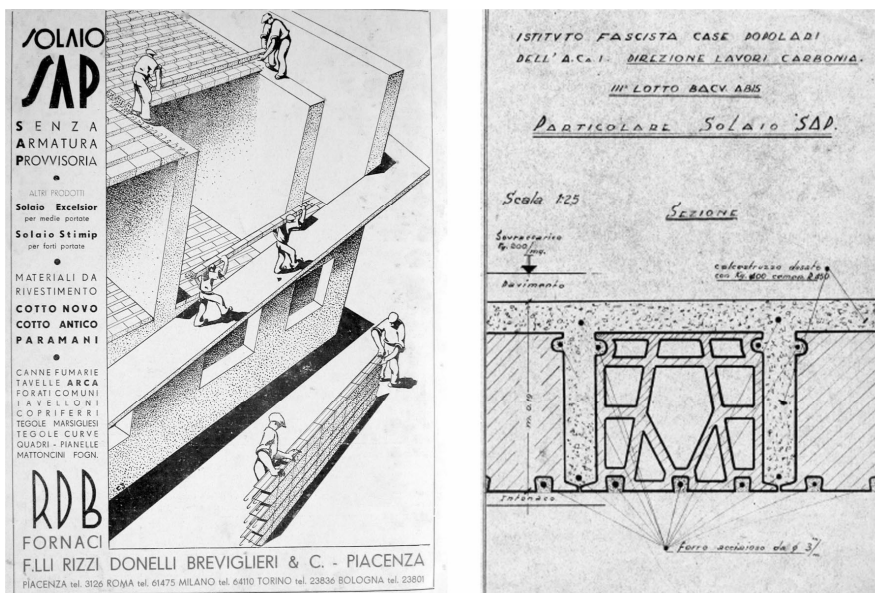


Figure 12. SAP prefabricated floor beams, advertisement from an historical review (left) and design detail from Carbonia archives (right) (AIACP)

Nuovo Villaggio di Carbonia

*Calcolo statico
delle strutture in cemento armato*

A) Tella del Direttore

I) Solai

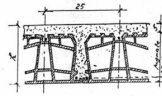
I solai costituiti da solette in cemento armato con nervature parallele e laterali forate. Bisulte Rsa vengono calcolate per un sovraccarico totale (accidentale o permanente) di $q = 100$ kg/mq. oltre il peso proprio.

Il forato Rsa viene fabbricato in 4 altezze da cm. 85-125-165-205 ed è munito di due scanalature ai lati della base inferiore e di una al centro di quella superiore. La sua larghezza, da asse ad asse è di cm. 85. Per la soletta viene adottato uno spessore uniforme di cm. 5.

L'armatura metallica è costituita dal solo ferro omogeneo da cemento armato con un carico di snervatura di 1500 kg/cmq. Il fondino metallico che trova sede nella scanalatura superiore ha funzione semplicemente esecutiva ed il suo diametro è proporzionale alle sollecitazioni che possono manifestarsi durante l'opera, come di peso in opera.

Nelle zone di momento negativo vengono aggiunti dei spessori metallici ad integrazione dell'armatura.

Il calcolo dei solai con laterali forati è identico a quello per le ordinarie solette di cemento armato.



Si considera una striscia larga quanto l'interasse di 2 laterali, cioè di 85 cm. nel caso presente, e su questa striscia considerata come trave elementare si ammettono le azioni esterne in relazione alle condizioni di vincolo.

Per la soletta sopra il 1° e l'androne si assumerà nella sezione di massima il momento del complesso appoggio di M^0 diminuito del $\frac{1}{3}$ per ragioni della continuità; per la soletta sopra le scanalature, gravate del peso del muro soprastante, si considererà le condizioni di semincastro per le sezioni di massima e di impatti ammettendo a momenti negativi di M^0 e M^0 come dalla Prescrizione regolamentare.

1) Solai sopra il 2° Piano

Soletta tipo (a)

$L = 2,45$ m.

Analisi dei carichi per mq di forato:

Peso $0,045 \cdot 2500 = 112,5$ kg

Segnali da 85 cm $\cdot 87$

Sovraccarico $= 200$

Carico totale per mq $\cdot 402,5$

e per ml di nervatura

$p = 402,5 \cdot 85 = 100$ kg

Il momento flessionale

$M = \frac{p \cdot L^2}{8} = \frac{100 \cdot 2,45^2}{8} = 750,15$ kgm

per $q/g = \frac{24}{100} \cdot 150$ kg/mq.

$L = 0,75 \cdot \frac{100}{150} = 0,5$ m

$p = 0,05 \cdot 1000 \cdot 0,5 = 5$ kg/mq $\cdot 248$ mm

Soletta tipo (b)

$L = 1,17$ m.

Carico come alla soletta tipo (a)

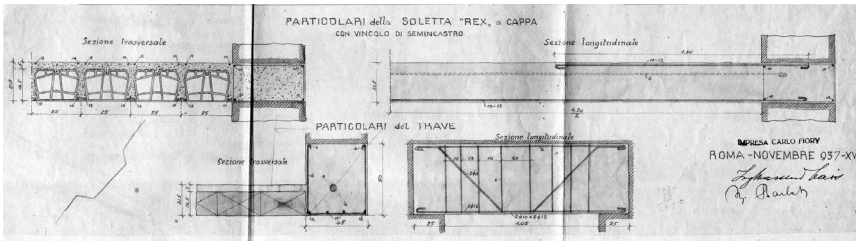
Momento flessionale

$M = \frac{p \cdot L^2}{8} = \frac{100 \cdot 1,17^2}{8} = 170,15$ kgm

per $q/g = \frac{24}{100} \cdot 150$ kg/mq

$L = 0,5 \cdot \frac{100}{150} = 0,33$ m

$p = 0,05 \cdot 1000 \cdot 0,33 = 16,5$ kg/mq $\cdot 248$ mm



Figures 13 and 14. Structural details (below) and some pages from the calculation book of the REX prefabricated beams relating to the mine company manager villa (top) (AIACP)

The light and resistant beams were put into their housings without the help of formwork but only with a divider and joined together with a final casting poured into the gaps, and the addition of further longitudinal bars. According to the patent this kind of floor should not need a reinforced concrete screed, relying, for the compression of the upper edge, only on the resistance of the brick. The question was quite controversial and, at that time, was the subject of heated debate between authoritative experts (extensively reported by Iori 2001); on the one side by those who praise the reliability of the 'Sap', whereas others consider the idea of doing without the upper slab as "villainous". In the yard of Carbonia a compromise was agreed consisting in prescribing at least a lower thickness varying between 3 and 5 cm. The Special Specification for the Primary School, extended with a few variants to all the other public buildings of the square, specifies that "only

types with a concrete screed with a thickness of at least 5 cm above the level of the hollow blocks will be admitted” (AIACP, C. 18), while in other documents the prescribed limit is 3 cm (AIACP, C. 26). What matters is that it was absolutely forbidden to eliminate the concrete screed entirely.

Detailed drawings and, in some cases, the design calculations for the Rex-type have been found, for practically all of the public buildings of the urban centre, whereas for housing the favoured type seems to have been Sap; the two types were virtually interchangeable, unless a single constructor, or the works management, had a special preference.

In this connection, the occurrence in which the young engineer Riccardo Morandi was involved is particularly significant. He, who later became one of the most important exponents of the Italian structural engineering and architecture, arrived in Carbonia as a consequence of a collaboration with the constructor Boero for whom he made the calculations for the reinforced concrete structures. A letter from Boero to Morandi, concerning a sloping-pitch roof, reads:

Company Store: need to conclude the way of executing the roof and we agree with you about the employment of the Sap or Rex floor. Stated beforehand that with these kinds of floors, with the loads we need, we can reach the clear span drawn in the plan, we prefer to use the Rex h:16,5 as it needs a lower quantity of iron in comparison with the Sap, and is cheaper than the latter. Keep in mind that the iron to be employed, according to the calculation, should be ingot iron Ø6 that is already present in the site...

This document is evidence of the common, and nearly alternative, use of the two types of prefabricated joist floors and confirms the preference accorded to the Rex, at least as far as the buildings of the urban centre were concerned; it also shows how the project choices were heavily influenced by the availability of materials in the yard, binding for example the height of the floors and imposing the diameter of the rods. Furthermore, it is evident that the scarce use of reinforcement bars is not an absolute parameter of preference but is *pondered* together with others, for example the total costs, and considering them in determining the final choice.

In the end the large employment of Rex and Sap roofs in the yard of Carbonia was due to the fact that they combined the following characteristics: extreme rapidity of execution, rationalization of the construction process with the prefabrication of the beams inside the yard; extremely limited use of wood for the formworks and optimization of the metal reinforcements.

CONCLUSIONS

We have tried to demonstrate, that the repercussions of autarchy on the building sector had many different, and often clearly contradictory, practical consequences. That because if, on one hand, there were urgent needs and the economic pressures deriving from the program, on the other hand

there was the scarcity of available means related to the specific area and to the imminent war. Furthermore, if we consider the contribution of the planner, with his search for forms that should aspire to modernity in a context that, on the contrary, hardly accepts all kinds of non-indispensable creative impulses, the cause of such a large variety of - sometimes really brilliant and significant - results and solutions is easily understood. The difficult balance between modernity and tradition, in spite of so many difficulties and delays, the swarming yard of Carbonia goes on with its activities till 1943, when the bombardments by the allies strike the mines, stop production and cause the suspension of the construction works, blocking for the most part the expansion of the town as it was expected by the extension plans. However, it represents an interesting case to be studied and to reconstruct a piece of the history of Italian yards and the building techniques of the thirties, thanks to the peculiarity of the conditions of the original project and to the rich documentation that still is available.

REFERENCES

- Archivio Storico dell'Istituto Fascista per le Case Popolari dell'A.Ca.I., Carbonia (AIACP)
Archivio Centrale dello Stato , Roma (ACS), Ministero per l'Industria e il Commercio (MIC), Direzione Generale per le Miniere (DGM)
Archivio Centrale dello Stato , Roma (ACS), Segreteria Particolare del Duce (SPD), Carteggio Ordinario (CO)
Archivio Storico Comunale di Carbonia (ASCC)
Archivio arch. Cesare Valle, Roma (ACV)
Archivio arch. Eugenio Montuori (AEM)
Archivio Storico Istituto Luce, Roma (AIL)
- 1937, "Le opere pubbliche in Sardegna. Il nuovo comune di Carbonia", *Nuoro Littoria*, 18 Settembre 1937.
- 1939, "Le città del carbone italiano", *L'architettura italiana*, n°3.
- 1940, "Carbonia, nuova città della Sardegna", *Architettura*, n°9.
- Bardelli, PG, Filippi, E, Garda, E, 2002, *Curare il moderno. I modi della tecnologia*, Venezia, Marsilio.
- Capomolla, R and Vittorini, R, 2000, *La costruzione moderna in Italia. Indagine sui caratteri originari e sul degrado di alcuni edifici*, Roma, EdilStampa.
- Casciato, M, Mornati, S, and Poretti, S, 1999, *Architettura Moderna in Italia. Documentazione e Conservazione*, Roma, EdilStampa.

Delogu, I, 1988, *Utopia e progetto*, Roma, Valerio Levi Editore.

Griffini, E, 1934, *Dizionario dei nuovi materiali per edilizia*, Milano, Hoepli.

Iori, T, 2001, *Il cemento armato in Italia. Dalle origini alla Seconda Guerra Mondiale*, Edilstampa, Roma.

Mariani, R, 1976, *Fascismo e città nuove*, Milano, Feltrinelli.

Piga, V, 1938, *Il giacimento carbonifero del Sulcis*, Roma, Stamperia Romana.

Sanna Antonella, 2005, *Carbonia: progetto e costruzione dell'architettura e dello spazio pubblico nella città razionalista di fondazione*, Unpublished Phd Thesis in Civil Engineering, Università degli Studi di Cagliari.

Sanna Antonello, 2004, *Tipi e Caratteri dell'abitazione razionale: il laboratorio Carbonia*, Cagliari, CUEC.

Tonini, V, 1943, *Terra del carbone*, Modena, Guanda.

