Giulia Marino

The CROCS Programme (1965-1973): Testing the Sustainability of Industrialized School Construction Systems

Il programma CROCS (1965-1973): l'edilizia scolastica industrializzata, un modello di sostenibilità?

Abstract
The Centre for the Rationalisation and Organisation of School Construction-CROCS was a major research programme initiated by the City of Lausanne. It was active from 1965 to 1973. The objective was to devise a method for constructing a large number of schools in a cost-effective and efficient manner using an industrialised construction technique. The CROCS steel construction system proved to be a significant success, with the construction of more than thirty buildings by the early 1980s, extending beyond the borders of Switzerland. The remarkable uniformity exhibited by the "series", encompassing administrative buildings, serves to underscore the extraordinary nature of these substantial industrial artefacts, a consequence of meticulous and rigorous planning. The present contribution seeks to interrogate the contemporary relevance of the series, whilst also considering the recent rediscovery of the principles of modularity and dry assembly, with a view to responding to novel models of sustainability.

Sommario
Attivo dal 1965 al 1973, il Centro per la razionalizzazione e l'organizzazione delle costruzioni scolastiche-CROCS è un vasto programma di studi avviato dal Comune di Losanna. L'obiettivo era lo sviluppo di un nuovo approccio alla costruzione di edifici scolastici economico ed efficiente, basato su processi industrializzati. Il sistema costruttivo in acciaio CROCS ha riscosso un successo considerevole, con oltre trenta edifici realizzati fino ai primi anni '80, anche al di fuori dei confini svizzeri. La coerenza della "serie", inclusi alcuni edifici amministrativi, dimostra l'eccezionalità di tali oggetti industriali prodotti su vasta scala, risultato di una pianificazione meticolosa e rigorosa. Il contributo si propone di interrogare l'attualità della serie per rispondere a nuovi modelli di sostenibilità, tenendo conto anche della riscoperta dei principi di modularità e di assemblaggi a secco.

Introduction

In 1965, the Municipality of Lausanne launched an extensive and ambitious study conceived as «a comprehensive operation to organise and rationalise school construction» (AVL, C4-34-1228. CROCS, Minutes of the meeting of 15 September 1971). This paradigm shift was intended to be radical; it was not just a matter of satisfying the quantitative aspects of the problem, but of addressing its complexity in full, taking into account diverse issues such as modern pedagogy and the industrialisation of construction simultaneously. In the spring of 1965, the City of Lausanne's Department of Public Works commissioned nine architects. At the end of the exploratory phase, four of them were selected to conduct a more in-depth study. United under an association independent of their respective agencies, the architects Jean-Pierre Cahen, Paul Vallotton, Michel-Robert Weber and Jacques Dumas formed the team that directed and coordinated all of the studies under the name CROCS-*Centre de rationalisation et d'organisation des constructions scolaires*.

Active from 1965 to 1973, CROCS's mandate was clear: «To develop a new method that aims to organise, industrialise and prefabricate in the specific field of school building construction in order to make better use of modern techniques, industry markets and available labour». In short, their objectives could be summed up by the slogan, «Build better, faster and more economically» through coordination of efforts and research, and by avoiding waste and the futility of isolated experiments and research (*24 Heures*, 1973). The stage was set; the keywords were rationalisation and series.

Lausanne: a laboratory city for industrialised school construction

This small town on the shores of Lake Geneva became the international capital of school research in the 1960s thanks to the work of the International Centre for School Construction-CICS. This organisation was founded by architects Jean-Pierre Vouga and Jean-Pierre Cahen (Yokoyama, 1996) with the aim of contributing to discussions initiated by UNESCO and the International Union of Architects-UIA during the post-war period. Pierre Bussat, who had just spent six months in England studying this country's pioneering methods of modular coordination in school construction (Bussat, 1963), worked closely with Jean-Pierre Cahen, the president of the UIA subcommittee on the influence of new construction methods on school buildings. Cahen was responsible for summarising a survey conducted among members in July 1965, just as the CROCS project was beginning.

The programme launched by the Municipality of Lausanne benefited directly from this preliminary knowledge and inventory analysis, which examined «all existing documents on [...] research currently underway in various countries on school buildings and their rationalisation» (Jaccottet, 1967). Identifying operations that «enjoy worldwide recognition» (Gross, 1964) thus became a fundamental working basis, making the CROCS programme a privileged place for experimentation thanks

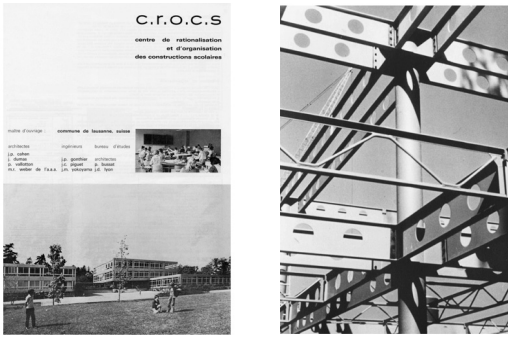

Fig. 1 - The Crocs programme presented in the Journal Recherche et Architecture, issue 8, in 1971, on the left, and the standard steel load-bearing structure proposed as part of the programme (AVL, Direction des travaux, file C2-1115 on the left and C4-1228 on the right).

to its multidisciplinary approach. Designed for the specific needs of the city of Lausanne, the CROCS system, in Figures 1 and 2, was also conceived to be adaptable to other programmes and very different cultural and normative contexts, a thorny issue given Switzerland's institutional organisation and its 26 cantons. The intention is clearly demonstrative, and this is no secret.

Flexible, therefore viable. An adaptable method for school construction

CICS studies taught us that the first decision concerns the theoretical approach: the fundamental choice between a system based on the criteria of closed or open industrialisation. These are two opposing concepts in the field of building rationalisation. Rather than envisaging a variable assembly of numerous standardised products (Bussat, 1963), open industrialisation was the obvious choice for CROCS. In terms of adaptation, the strict application of the principle of modular coordination allows for greater interchangeability of industrialised components and subsystems, which is a major advantage in terms of reproducibility. Secondly, the design process is entirely modulated in plan and section according to a modular grid that corresponds to the international module of 10 cm, consisting of two grids superimposed on a 60 cm · 60 cm base (s.a., 1975), in Figure 2. This provides excellent guarantees in terms of the versatility and internal flexibility of buildings. This principle also aligns perfectly with the recommendations of the new pedagogy through «the gradual abandonment of the organisation of teaching in fixed classes, replacing it with greater flexibility in the grouping of students» (Lyon, 1978).

We are therefore interested in the experiences of Anglo-Saxon countries, such as the English CLASP-Brockhouse systems, a success story in the history of school industrialisation, and SCOLA and the American SCSD, with their modular and flexible designs. Research was also conducted on the main Swiss experiences in this

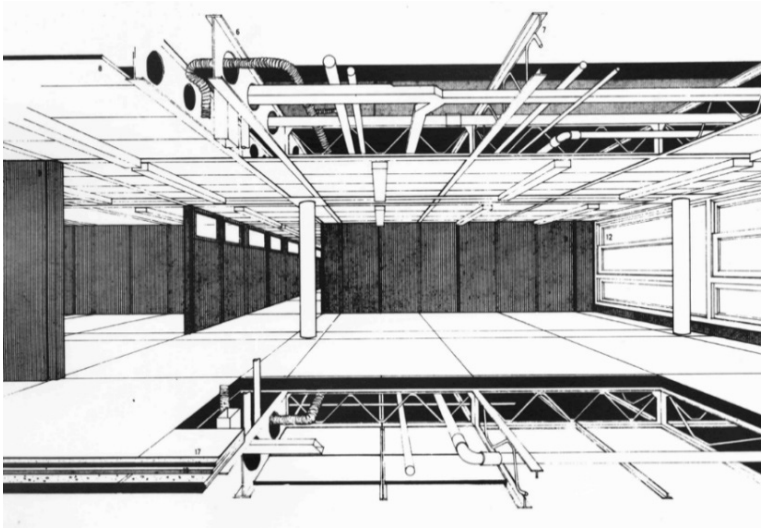

Fig. 2 - Interior design of a CROCS model school: modular structure, flexible movable partitions, reversible utilities distribution (AVL, C2-1115, CROCS, Directives fonctionnelles, mai 1968).

field, covering all construction techniques. These range from the licensed application of the Barets heavy prefabrication system in a large-scale programme in Geneva, to the processes developed by the Swiss company Variel. Initially, these were in steel, Variel-System-58, and later in reinforced concrete, Variel-Beton-System.

The team of engineers who joined CROCS in 1967 sought to create a structure that was independent of functional spaces and capable of spans of around 14 m to 18 m, with the position of the pillars being arbitrary. Heavy prefabrication was ruled out "due to difficult connections", and the engineers, Jean-Pierre Gonthier, Jean-Claude Piguet and Jean-Marie Yokoyama, «deliberately focused their research on metal systems» (AVL, C4-31-1228. Gonthier J.-P., Piguet J.-C., Yokoyama J.-M. Programme CROCS. Proposition d'un système structurel, 9 july 1968). This choice was motivated by the systems' lightness, speed of dry assembly, high strength and the wide possibilities for industrialisation due to the low tolerances of the construction elements, see Figure 3.

Fig. 3 - Marx Lévy, Jean-Pierre Vouga architects: Bergières school complex in Lausanne, 1969-1976, construction site (AVL, file C4-38).

A system that complies with the laws of statics and rationalization

The English CLASP system is an essential theoretical reference, but it is criticised in favour of a more open design, namely, a bidirectional structure, which is considered to offer greater internal organisational flexibility. Fritz Haller's early research on modular structures was promising, as evidenced by the cantonal school in Baden from 1958 to 64. Close attention is paid to the construction of the Auen school complex in Frauenfeld by Barth & Zaugg from 1962 to 1969. Architects also admire the stool structures that allow for varied and dynamic plans in Jean Prouvé's schools. Experiments are referenced which, through a bidirectional design based on the Nenk System[1], allow for a homogeneous distribution of stresses throughout the structure. This principle ensures that the self-supporting system complies with the laws of statics and building rationalisation while also meeting the desired criteria of flexibility and adaptability in plan and section, the true leitmotif of the process.

Thus, the load-bearing structure, consisting of rigid frames made of prefabricated bolted steel elements, tubular columns filled with concrete and double main beams in lattice or crenellated form, is aligned with the main modular structure to create a structural field of 9.60 m in both directions, as shown in Figure 4. The columns are topped with a factory-integrated "mushroom arrangement" and are embedded, meaning the structure is self-braced. This allows for great freedom in the internal organisation and avoids the need for cross-braces in the space.

Fig. 4 - Félix Porcellana architect: Grand Vennes school complex in Lausanne, 1970-1977, construction site (AVL, C4-38).

The characteristics of the metal construction are exploited in the design of the horizontal partitions: the hollow floors are formed by a secondary structure of crenellated R-Träger beams, which are assembled by welding on a ground template and completed by non-collaborating cement slabs. The 60-centimetre-thick technical void in the floor accommodates all the fluids. This ensures a uniform and coordinated distribution of the networks with the other elements of the construction, eliminating any "fixed points" and allowing the interiors to adapt to future changes in use.

The theme of the "energy blanket" by the horizontal distribution of fluids throughout the thickness of the ceiling, as a guarantee of interior flexibility, a true invention of the 20th century, is admirably adapted here, with the "Californian schools" SCSD and Fritz Haller's USM systems serving as references.

Finally, the use of lightweight, removable interior partitions follows the same logic to promote the reversibility of spaces. Continuous flooring and completely independent ceiling elements facilitate the free arrangement of partitions, which are systematically installed on the modular line in line with the main and secondary beams.

Dimensional range and composition rules

The CROCS specifications for building envelopes state that «architects are encouraged to use lightweight construction elements that are finished in the workshop and dry-assembled in order to reduce the load on the structure and facilitate rapid implementation» (Archives Ville de Lausanne, C4-34-1228. CROCS, Minutes of the meeting of 15 September 1971). The curtain wall technique was also chosen because it gives future project managers a certain degree of control over the buildings' appearance. The CROCS specifications impose two variants: within or outside the modular axis. Clear guidelines are provided on measures to control interior thermal comfort: the glazing must be insulated, external sun protection must be effective and caulking must be executed perfectly. However, the specifications state that «the implementation technique is not imposed». The envelope may be constructed from complete panels or smaller elements mounted on vertical rails. as shown in Figure 5, the divisions of the façades are defined by a dimensional grid that gives architects considerable freedom in terms of composition and materials, opaque or transparent. The type of openings is not specified, but sliding or guillotine windows are recommended [1]. The aim is therefore simply to provide general guidelines that do not hinder the urban and architectural freedom of composition of the various designers [2].

This freedom is at the heart of the CROCS system. «The school building becomes a kind of metal construction set composed of modules with standardised dimensions» (s.a., 1971); these can then be adapted according to the desired architectural style, see Figure 6, allowing the architect to assemble the volumes and compose the façades. Unlike Fritz Haller's commercial strategy for distributing USM processes, where prototypes are sold under licence, CROCS aims to promote genuine mass

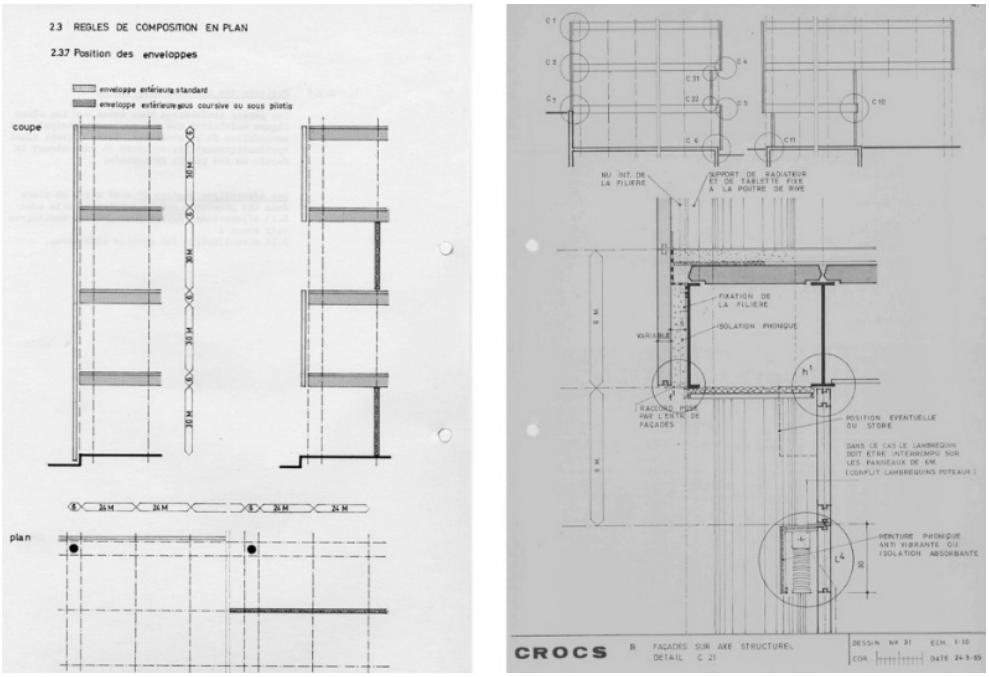

Fig. 5 - CROCS programme: specifications concerning envelope elements, their position in relation to the load-bearing structure, their material composition (Direction des écoles, file C2-1116, Directives façades, september 1969).

Fig. 6 - The variety of envelope writing solutions resulting from the guidelines of the CROCS programme (AVL, C4-38), on the left and in the center, and picture by G. Marino, on the right.

production. Rather than entrusting the project to a designated company, as was the case with Brockhouse for CLASP schools, the aim is to define all the client›s requirements in advance with sufficient precision to enable turnkey bids that are not a gamble to be requested. Jean-Pierre Cahen, one of the programme›s initiators, is behind a CROCS industrialised school construction company that will be responsible for building several schools. However, this structure, combining the RS-Réalisations scolaires design office and MULTIBAT, a company acting as general contractor, will not have exclusive rights to implement the programme, as demonstrated by the multitude of architects and companies invited over the years.

Preserving CROCS schools. Industrial series and sustainability

In 1973, after eight years of theoretical and applied studies, CROCS's results were compiled into three notebooks, one for each of the study's three phases. These were entitled 'Functional Guidelines', 'Project Guidelines', and 'Implementation Guidelines'. As early as 1967, CROCS's operational architect, Jean-Pierre Cahen, had used the construction of the Beausobre secondary school in Morges as a prototype for testing certain hypotheses and clarifying the wording of the tenders (Lenssen, 1973). During CROCS's mandate, three other pilot projects were constructed in Lausanne: the large Coteau-Fleuri school complex, architect G. Haunin, 1971, La Rouvraie school complex, architect F. Sillig, 1972, and La Vallée de la Jeunesse school complex, architect J. Dumas. The results were positive, with construction times of nine to fourteen months and costs 10 to 15% lower than traditional prices. Following this success, were held an architectural competition for the Bergières school complex and a competition for general contractors at the Yverdon gymnasium to gauge the acceptance of architects and contractors. Once again, the results were conclusive. Other projects will follow, spreading to several regions in Switzerland and abroad, an exceptional feat.

With around 30 schools listed, the CROCS programme has achieved remarkable results. This is a first in Switzerland. Due to the socio-economic reasons behind the programme, as well as the constructive intelligence of its many manifestations, the historical value of the CROCS programme, in terms of the industrialisation of construction and the history of architecture, is undeniable. The "series" was recognised in the thematic inventory of 20th-century heritage in the canton of Vaud in 2017-19. The importance of CROCS schools in the international landscape of research on industrialised school construction is undeniable. The research carried out as part of the Lausanne Municipal Council programme systematically took international experiences into account, particularly in England and the United States. This supports a model that was central to concerns during the 1950-1970 period and constitutes important testimony from the perspectives of construction history and the history of engineering. These two aspects are inseparable in the industrialised construction process.

Fig. 7 - Michel-Robert Weber architect for RS and Multibat: the Yverdon gymnasium, part of the CROCS programme, 1969-1975, upon completion (Vaud Cantonal Archives, Jean-Pierre Vouga collection, file 197), on the left, and today, following an energy-efficient renovation of the building envelope that was highly destructive (picture by G. Marino), on the right.

Fig. 8 - Helfer Architekten, Jacques Dumas et Serge Pittet: the École hôtelière de Lausanne, part of the CROCS programme, 1973-1976, upon completion (École hôtelière de Lausannes, historical file), and today, following an energy-efficient renovation of the building envelope that was highly destructive (picture by G. Marino) on the right.

However, most of the schools have undergone major and irreversible transformations over the last twenty-five years. Reinterpretations, replacement of façades, "wrapping", and ill-advised extensions are, unfortunately, commonplace as shown in Figures 7 and 8. Against this disheartening backdrop, the remarkable Bergières school complex stands out, in Figure 9. This beautiful complex, which is integrated into the topography, was one of the most successful of its time and is perfectly preserved today, a rare and precious fact given the mistreatment of CROCS schools in recent years.

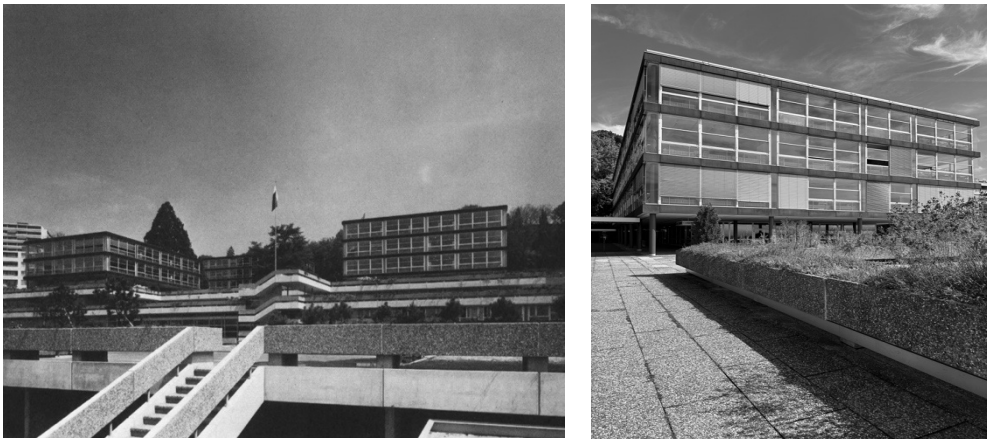

Fig. 9 - Marx Lévy, Jean-Pierre Vouga architects: the Bergières school complex in Lausanne, 1969-1976 is one of the last complexes whose original architectural qualities are still recognisable today. Upon completion (Architecture Suisse AS, n° AX2, 1977) on the left, and today, (picture by G. Marino), on the right.

As with 20th-century heritage in general, attitudes towards CROCS have changed gradually but steadily, with an increasing recognition of their importance to the history of construction. Paradoxically, the repeated destruction of industrialised schools has contributed to this reappraisal, at least for those buildings that have withstood the wave of hasty transformations. The recent competition for the renovation and extension of the Perrosalle school centre in Ollon, one of Jean-Pierre Cahen's last projects in 1974-85, openly recognises the «exceptional quality of the original sash windows [...]» and requires their preservation (Ollon, 2017), acknowledging them as a significant achievement. However, while indoor air quality does not appear to be an issue, as natural ventilation is provided by guillotine windows and grilles in the transoms above the doors, energy performance is criticised, particularly due to the lack of inertia in the curtain walls.

The paradigm shift in construction that took place following the 1970s oil crises abruptly interrupted the CROCS series and called light industrialisation into question throughout Europe. These issues continue today, revised and exacerbated in the policy of drastically reducing energy consumption. Lightweight construction, regardless of its actual performance, is particularly targeted. The CROCS schools are proof of this. While the principle of adaptability in classroom interior layouts has clearly proven its worth over the years, including in terms of fire safety, the «construction model is considered obsolete» (DFRE, 2021): schools are interested in numerous interventions where the load-bearing structure simply supports new, high-performance "fantasy" envelopes, erasing the inherent modular features of the process.

However, recent academic work (Hoffmeyer *et al*., 2018) has demonstrated with supporting calculations that localised thermal improvement measures coupled with the rationalisation of technical installations can yield excellent results in terms of user thermal comfort and energy savings according to the legal standards while preserving the materiality of buildings, i.e., their intrinsic heritage value. The thinking on the economic operation of buildings that CROCS architects had incorporated upstream, starting with the rationalisation of networks, simply needs to be extended or updated. This has enormous potential.

Recently, the cantonal authorities launched a series of architectural competitions marking the rediscovery of the 1960s mass school construction approach in a contemporary ecological version using wooden construction systems. In this context, it would be beneficial to highlight the latest examples of CROCS's work. The advantages of dry construction in terms of reversibility and scalability also deserve to be recognised, including in terms of sustainability, through the possibility of simple adaptations with minimal grey energy expenditure. While the existing project is rightly held up as a model for the sustainable and inclusive city of tomorrow, the flexible design of this architecture can inspire effective and economical approaches to building adaptation over time.

Acknowledgments
This contribution is part of the research project: "Reload, rethinking procedures and architectural practices for a silent transition", led by Professors Giulia Marino (Catholic University of Louvain, LAB Institute, Brussels) and Franz Graf (Accademia di Architettura, Università della Svizzera Italiana, Mendrisio). The project is being developed as part of the National Research Programme NRP 81, 'Baukultur: For an ecological and social transition of the built environment', which is funded by the Swiss National Science Foundation. It will run from 2025 to 2028.

Archives

Archives Ville de Lausanne (AVL), Direction des travaux, file C4-34-1228, Jaccottet G., Bulletin du conseil communal, 14, meeting of 11 October 1967.
AVL, C4-31-1228, CROCS, Group of Engineers (J.-P. Gonthier, J.-C. Piguet, J.-M. Yokoyama), Proposal for a Structural System, 9 July 1968.
AVL, C4-31-1228, CROCS, Red Book, document 1, Structural work and finishing work, August 1968.
AVL, C4-34-1228. CROCS, Minutes of the meeting of 15 September 1971.
AVL, C4-38, iconography 1965-1971.
AVL, C2-1115, CROCS, Directives fonctionnelles, mai 1968.
AVL, Direction des écoles, file C2-1116, Directives façades, september 1969.
École hotelière de Lausanne Archives, historical files.
Vaud Cantonal Archives, Jean-Pierre Vouga collection, file 197.

Bibliography

Bussat P. 1963. *Die Modul-Ordnung im Hochbau*. Struttgart: BSA/FAS SIA, CRB, Karl Krämer Verlag.

Ollon. 2017. Groupe scolaire de Perrosalle. Concours de projets d'architecture, rénovation, transformation, agrandissement, programme du concours. Commune d'Ollon.

DFRE. 2021. Gymnase du Chablais, Aigle, concours de projets d'architecture et d'ingénierie, rapport du jury. DFRE, Canton de Vaud.

Gross R. 1964. Neue Tendenzen im Schulbau. Schweizerische Bauzeitung, 28, 489-498.

Hoffmeyer M., F. Graf, G. Marino, *et al*. (Eds.). 2018. *Sauvegarde et extension d'un groupe scolaire CROCS. Le complexe des Bergières à Lausanne (M. Lévy, B. Vouga, 1968-75)*. Master Project SAR-EPFL.

Lenssen P. 1973. CROCS. Un système suisse de construction scolaire industrialisée. OCDE, PEB-Programme sur la construction scolaire, 3, n.p.

Lyon J.-D. 1978. Construire l'École, construire des écoles. *Études pédagogiques: annuaire de l'instruction publique en Suisse*, 69, 3-13

s.a. 1971. CROCS, Centre de rationalisation et d'organisation de la construction scolaire. *Recherche et Architecture,* 8, 1-8 (reprint).

s.a. 1971. La nouvelle école primaire de La Coudre aura un bassin de natation. FAV-Feuille d'Avis de Neuchâtel, n.p.

s.a. 1975. Le système CROCS, 1975, *Informateur de la construction*, 3-4, 1975, 35-37.

s.a. 1977. Groupe scolaire des Bergières. *Architecture Suisse*, n° AX2, n.p.

Testa C., Schmid T. 1969. Systems Building. Artemis.

UIA. 1963. Report of Sub-Commission II on the International School Building Centre. School Building Commission, Hamburg, May 1963.

Vouga J.-P. 1972. CROCS : une mission d'homme d'orchestre. Adapter l'architecture à la pédagogie. L'Habitation, 7, 32.

Yokoyama J.-M. 1996. † Pierre Bussat 1921-1996 architecte EAUG-SIA-FAS. Ingénieurs et architectes suisses (The Swiss Bulletin of Engineers and Architects), April 24, 122(10), 158.

Web references

[1] https://architecturesuisse.ch/fr/as/003/systeme-de-construction-crocs/

Notes

[1] Developed in Great Britain by the Ministry of Public Buildings and Works, the NENK system is designed to adapt to a wide range of uses, thanks to a three-dimensional bidirectional structure on a 1.20 m grid. The lightweight steel frame on traditional concrete infrastructures can accommodate a wide variety of façade panels, with structures in wood, aluminium or concrete.