



WHAT IF? WHAT NEXT?

SPECULATIONS ON HISTORY'S FUTURES

SESSION 1B

MODES OF ARCHITECTURAL HISTORY

Architectural History Through Technology and Material Culture

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HISTORICAL AND GEOGRAPHICAL CONTEXTUALISATION OF RAMMED EARTH ARCHITECTURE

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This study investigates modern and contemporary uses of rammed earth (RE) constructions in different geographical contexts, with a specific focus on the Australian. The objective is to understand the recently renewed interest in such construction technology. RE appeared independently in different geographical contexts across history. Then it diffused, throughout several regions, diversifying the uses of the materials and construction techniques. During the 1900s, the use of RE was confined to a few contexts. The most significant uses during the 1900s were documented in in Australia and USA. Although such limited uses of RE may be perceived in the literature as having declined as a consequence of technological advancements during the 1900s, RE may have actually benefitted from its coexistence with other construction technologies in those modern contexts. The Australian experience in RE is a unique and precious example of such coexistence. Over the last two decades, RE has been the object of extensive architectural practical research, rehabilitating and developing the diffuse knowledge and technical practices of RE. This study gives an historical overview of RE architecture, mapping its time and space during the 1900s. The study integrates the current literature within an original framework which includes analysis of modern and contemporary buildings, and the analysis of secondary data, archival searches, and interviews, aiming toward extending an enhanced understanding of RE technologies used in contemporary architecture. Throughout the analysis of the Australian practice, this study presents a reinterpretation of the niche uses there of RE during the 20th century, and it sets up a working hypothesis on the definition of contemporary RE architecture investigating to what extent modern architecture and technological transformations created the base for a new tradition of RE.

Introduction

Rammed earth (RE) is defined here as the construction methods for wall systems involving the compaction of soil blends in consecutive layers within temporary formwork.¹ The use of RE in architecture developed relatively late in the history of construction technology, as it involves manufacturing, fixing and compaction methods.² RE appeared independently in China and in the south Mediterranean regions during the Bronze ages,³ then the technology evolved and diffused over time throughout diverse geographical contexts. Several historical and environmental factors contributed to such regional adaption of RE constructions throughout the centuries – the climate, the local geographical features⁴, the landscape as well as social and economic conditions.

In the late 1700s and early 1800s, in the south of France⁵, where RE had become endogenous in ex-urban areas throughout the centuries, RE was the object of the first scientific studies. Such studies began with the work of the Lyons builder, François Cointeraux. Cointeraux's work inspired further research in central Europe and in the south-east of USA, where RE was common in farm buildings and rural cottages around 1810s-60s.⁶ The outcome of such a wave of studies was a number of publications turning the empirical knowledge of RE into a substantial theoretical corpus of knowledge. In Australia, the use of RE was introduced in the 1800s,⁷ and it was a resource in the early building process in several agricultural regions. This overview of the main transfer processes of RE technology through the centuries, and different geographic regions, emphasises that the historical uses derived from regional adaption of the technology to different geographical contexts, denoting an intrinsic, localised nature of RE architecture.

In the 1900s, RE was used only in a few niche contexts, mostly located in USA and Australia. Albeit limited, such uses had a remarkable impact on the enhancement of RE technology, as RE was introduced in urban modern contexts. Such uses contributed to integrate RE with other construction technologies. Since 1976, in the south-west of WA, RE was explored as a contemporary building material. Between 1980s-2000s, the use of RE appeared internationally in contemporary architecture. Nowadays a number of contemporary architects include RE in their personal research, with different motivation and level of engagement with the material.

This study traces a historiographic frame of modern and contemporary uses of RE. The study is outlined in three parts: (i) *niche uses of rammed earth throughout the 1900s*; (ii) *toward sustainable architecture*, and (iii) *rammed earth in contemporary architecture*. The first part illustrates the significance of the limited uses of RE throughout the 1900s (before the 1970s) in Australia and USA; the second part introduces to the rehabilitation of RE since the 1970s in the south-west of WA, and the third part is a critical discussion on the current global phenomenon of RE architecture. Throughout the detailed analysis of the Western Australian practice, and the broad study of the international experiences, this study presents a reinterpretation of the niche uses of RE during the 1900s, and it sets up a working hypothesis on the definition of contemporary RE architecture investigating to what extent modern architecture and the technological transformations of the 1900s created the base for a new tradition of RE. This study investigates RE architecture (*ârche-técton*) as a system of *ideas and forms*⁸ in a specific geographic context,⁹ and RE technology (*tékhne-logía*) as a system of processes that generate consistent methods of design and construction.

To the best of this author's knowledge, only a few studies¹⁰ broadly address modern and contemporary uses of RE. The lack of comprehensive historical descriptions of RE architecture may be the result of the fact that the 1900s is perceived as the time of a split in the historical uses of RE.¹¹ This study makes an effort to reconcile modern and contemporary histories of RE architecture. Recalling Kubler's idea of history,¹² one may notice that the definition of the current phenomenon of RE construction cannot proceed without tracking its precedent uses, as contemporary RE buildings may be theoretically rooted in such precedents.

Niche Uses of Rammed Earth in 1900s

Modern RE Projects in USA

RE was introduced in the USA during the 1700s and in the period 1810s-60s, its use being common among the agricultural society in the agricultural regions of Virginia, Maryland, Louisiana and South Carolina. In 1851, in Stateburg (South Carolina), the Church of Holy Cross, designed by architect Edward C. Jones,¹³ was built in RE.

In 1924 engineer K. Ellington published *Modern pisé-building: House-building with Compressed or Rammed Earth*, a comprehensive study on RE construction aimed at providing practical instructions to builders and owner-builders. Ellington's book is probably the first to introduce the concept of modern RE, which underpins a progressive long-term view of such construction, with a clear idea of the potential of RE as part of modern construction technology.

Nevertheless, the old way served well for its time [...] In modern pise' building we must use tools of improved type and in other ways to make procedures as time saving as can be done without detriment to the quality of the work.¹⁴

In 1926 Thomas A.H. Miller for the Division of Agricultural Engineering conducted a survey of the church of the Holy Cross.¹⁵ The survey signalled a relevant wave of studies supervised by the Government. In 1926, due to the local interest generated in the technology, the US Department of Agriculture issued a document to provide technical support to builders interested in RE: the *Farmer's Bulletin 1500: rammed earth walls for buildings*.¹⁶ In 1939, engineer F. MacDonald published his studies on cement stabilised RE: *Terracrete*. The inclusion of 2-4% of cement in RE blends enhanced the load-bearing capacity, and the resistance of the material to weathering¹⁷.

During the Great Depression, RE was used in experimental projects managed by the National Agency as an output of Roosevelt's New Deal.¹⁸ One of the first sites was Gardendale Grand Olive near Birmingham, Alabama. The project involved the construction of several houses; seven of those houses were labelled as experimental and were built in RE.¹⁹ Architect and engineer T. Hibben was in charge of the design of the experimental houses.²⁰ Hibben's design included relevant modern architectural features compared with the traditional timber frame and brickwork buildings – jutting out volumes lightened by full height glass doors, and horizontal roofs, as shown in Figure 1.



Figure 1. Hibben's rammed earth houses at Gardendale Grand Olive, Alabama. Source: Library of Congress, Prints & Photographs Division, FSA/OWI Collection. Reproduction number: (right) LC-USF34- 025290-D [P&P] LOT 1611, (left) LC-USF34- 025291-D [P&P] LOT 1611.

During the 1930s Frank Lloyd Wright elaborated a practical interest in the use of local materials and in 1942 Wright designed the Cooperative Homestead, in Michigan, a housing project entirely designed in RE.²¹ The selection of RE derived from the natural thermal and aesthetic qualities of

the material together with the local availability of suitable soils. Wright commented on the choice of RE for the Cooperative Homestead as follows:

Here you have good insulation – great protection from the elements; a possible economy, too, because you do not have to finish any outside below the window level. You do not have to finish the inside walls either if not so inclined. I think it is an excellent form for certain regions and conditions. An actual economy and preservation of the landscape.²²

The continuity of the Australian experience

In Australia, RE was introduced firstly in Tasmania in the 1820s.²³ Relevant early uses of rammed earth were documented in agricultural regions in NSW, in Victoria and Western Australia.²⁴ RE was essentially a reasonable alternative, as building material supply of bricks, stone and concrete were not feasible options for technical or economic reasons. The use of RE in agricultural regions was supported by local authorities, as demonstrated by several articles published in local newspapers such as the *1905 Agricultural Gazette of New South Wales* and in the *Farmers' Handbook* issued by the Department of Agriculture, NSW in 1911. The greatest number of RE buildings in the early 1900s was in NSW, being mainly cottages and homesteads.²⁵ The Farrer Barn, built in Cowra in 1906-1907, is a substantial example of such uses of RE. It is a three-roomed building with massive RE walls, covered with gabled corrugated iron roof supported by timber truss, and encircled by a timber post veranda.²⁶ The Shire of Harden counted hundreds of RE cottages built between the 1890s and 1910s, which were still inhabited in the 1940s.²⁷

In the 1910s, there was a considerable wave of building development in several towns that had been founded in the 1850s. In the new settlements, civic and community buildings catalysed the building process. As part of the local technical culture, RE may have been sporadically used as one of the locally available technical options in the construction of community buildings, as in the case of the Winstonwood Church, built in 1901 in Murray.²⁸ During the decades of the 1910s and 1920s, an interest in RE emerged among eminent personalities, professionals and local politicians, in Victoria and in the Riverina region.²⁹ Architect A.C. MacKnight contributed to such spread of interest and a few of his projects were published in the *Australian Home Beautiful* in the late 1920s.³⁰

In 1934, Justus Jorgensen founded the Montsalvat artist colony near Eltham, Victoria.³¹ The early buildings were of a revivalist approach, and were technically empirical. Nevertheless, such buildings had the merit of raising themes regarding the sustainability of the building processes for Australian communities. The research conducted in Eltham critiqued the disconnection between the local buildings and the landscape. Since the 1940s and 50s, more refined research, aiming toward a re-definition of the domestic space in the local environment, contributed to define localised, modern formal systems that were deeply responsive to the environment and connected with the landscape. Earthen materials, and local timber, become tools to create logical connections between the building, the context and the landscape. In the 1940s, architect and engineer G. F. Middleton initiated his building research at the Commonwealth Experimental Building Station and he visited the Eltham community extensively during his research.³²

The practical outcome of the Australian and American experiences

The practical outcomes of the American and Australian experiences in RE technology, in the first half of the 1900s, resulted in the first attempt at the standardisation of RE construction methods. In 1948, the US Bureau of Standards published the results of a test campaign on mechanical thermal and durability properties of earthen materials as BMS 78. The test campaign was conducted by L. W. Herbert, H. Ambrose, E. Hubbell and R. Dill. In 1952 in Australia, the first code related to earthen construction was issued as CSIRO Bulletin 5, the result of the research conducted by Middleton. Bulletin 5 identified the potential issues of building with earth, and provides a range of high-standard construction practices that can be applied under different circumstances at the discretion of the builder.

Toward Contemporary Rammed Earth: Stabilised Rammed Earth in Western Australia

From the 1970s, cement-stabilised RE was explored as a local building material in the south-west of WA. The developing RE technology generated a new local tradition of RE, driven by a concern for sustainable construction. The tangible results of this technical culture of contemporary RE were (i) a diffused heterogeneous heritage, (ii) remarkable technological enhancements and upgraded construction methods, and (iii) a solid network of professionals that brought RE into the construction industry.

The original experimental work is linked to builder Giles Hohnen and architect Tom Roberts in Margaret River, and engineer and builder Stephen Dobson firstly in Darwin (NT) and then in the south-west of Western Australia. In 1976, Dobson built his first RE house in Darwin, being interested in cement-stabilised RE as a cyclone-proof material.³³ Hohnen and Roberts were interested in the material as a response to the technical issues of the built environment in Margaret River, where the long, wet winter season made constructions suffer from severe humidity.³⁴ They were interested in the aesthetic and technical qualities of RE, and they were researching alternative solutions to the standard, lightweight, timber-framed houses. They were aware of the themes addressed in Eltham, and they were motivated by the idea of using local materials to provide comfortable and energy-efficient houses.³⁵ Their research was originally based on Middleton's work, and a book on Israeli rammed-earth construction that Tom Roberts encountered during his academic studies in Perth.³⁶ This wave of research can be described through five main periods that detail the main technical advancements and correspond to different periods of architectural research: the original buildings (1976-77); the first phase of research (1978-1983); the consolidation phase (1984-1992); the diffusion phase (1992-early 2000s); and the current research (early 2000s-ongoing).

The original building in Margaret River, dated 1976, was a shed in the Cape Mentelle winery estate. The shed was built employing a simple construction technology, involving the use of the Middleton formwork system, hand-mixing and hand-ramming processes, and soil stabilisation at 2% of Portland cement.³⁷ In 1977, Hohnen and Roberts initiated the design of the first building at Cape Mentelle winery estate (Fig. 2), employing a similar construction technique. The building is a typical cellar with massive walls and gabled, metal-sheeted roof. The RE walls are framed in between the concrete foundation and the concrete top-beam that attached the jarrah roof structure. Although the walls show the attachment line of two sections, the thin RE layers create a pleasant effect emphasising the horizontal lines.



Figure 2. (L) original building at Cape Mentelle built 1977; (R) detail of the wall. Photographs V. Strazzeri.

During the first phase of research, the introduction of Bobcat mixing, pneumatic ramming, and experimental innovative formwork systems, made construction methods more effective in terms of time and costs. Several buildings were completed in the south-west of Western Australia at this time, including private residences and commercial buildings. Many of these buildings show

traditional architectural features such as hipped or gabled steel roof systems, supported by the typical jarrah structure, and a wooden post veranda.

The Sandalford Winery (Fig. 3), built in 1983 in Margaret River, shows massive RE walls with an overhanging hipped metal roof supported by jarrah beams and joists. The building is encircled by a wooden-post veranda. On one side, the full-height glass doors open onto the vineyard, and on the west side there is an RE fireplace. The warm tones of the RE walls, together with the jarrah wood tones, make the indoor space comfortable and welcoming, and connect with surrounding native trees and the vineyard.



Figure 3. Sandalford Winery, Margaret River. Photographs V. Strazzeri.

In 1983, after several experimental versions, Hohnen designed the prototype of an innovative formwork system, which was fine-tuned in 1984 and entered the industry the year after.³⁸ The two designs (dated 1983 and 1984 respectively) became the new standards.³⁹ The 1984 system is comprised of steel frame and plywood panels and through bolts. Compared with the Middleton system, it allowed for a higher level of tolerance and higher precision in forming up the walls, leading to reduced construction time.⁴⁰ Figure 4A and B shows the Middleton formwork and the new system (C). During this consolidation phase, hundreds of buildings were constructed in WA and throughout Australia, by a rising number of building firms, networking as *Affiliated Stabilised Earth Group* (it counted about 15 firms and operated till the early 2000s).⁴¹ The local industry gained confidence in the use of cement stabilised RE; it provided updated specifications and set new quality standards for RE walls. In addition, CSIRO Bulletin 5 was revised in 1982, including new advancements in mixture design.



Figure 4. (A) Tom Roberts during the construction of the Shed, at Cape Mentelle Winery Estate, Middleton Formwork system 1976; (B) G. Hohnen during the construction of the Shed, at Cape Mentelle Winery Estate, Middleton Formwork system 1976; (C) The new formwork system. Courtesy of G. Hohnen.

RE construction technology draws on craftsmanship-oriented fabrication process that, on the one hand, allow for high quality control, and on the other hand emphasise the “made in WA” aspect as an intrinsic value of the new buildings. Since the 1980s, a number of architects included cement stabilised RE in their personal research, using different reasons and levels of engagement with the materials, and expanding the network through the country. These include Chris Willcox, Theo Mathews, Ehd Architects, Archterra, Hassel Studio, Tim Wright, Troppo Architects and others, whose personal research in terms of architectural design contributed to validate the potential of RE in contemporary architecture, with the material being explored in a contemporary architectural language using insights of sustainability. The use of cement-stabilised RE has become a distinctive trait of the local built environment, as stated by the Margaret River- Augusta Heritage Inventory regarding the St. Thomas More Catholic Church in Margaret River (Fig. 5) and the Lumen Christi Catholic Church in Augusta (Fig. 6) designed by Hodge & Willcox in 1982 and 1985 respectively. In the Lumen Christi Catholic Church, the use of crushed limestone contributes to create strong connections with the landscape. The creamy colour of the rammed limestone walls, the full-length ribbon window above the walls, the coloured glass, and the light colour of the details emphasise the brightness of the predominant light condition of the site. The patio opens on the wonderful landscape of the Hardy Inlet.



Figure 5. Saint Thomas More Catholic Church. Built in 1983, Margaret River. Photographs V. Strazzeri.



Figure 6. Lumen Christi Catholic Church, Augusta. Photographs V. Strazzeri.

RE was explored and used in combination with other construction technologies, such as steel technology. The Transperth O’Connor Bus Depot (Fig. 7) 1994, in the Perth metropolitan area, is an outstanding industrial building that integrates stereometric RE volumes with glass walls and a steel truss frame. The complex includes the bus hangars and the office area, comprised of curved and squared RE volumes opened on one side by a glass wall, protected from the sun by the

extended RE walls and overhanging flat roof. The hangar section is comprised of a tall, white-painted steel frame with circular-section columns and thin trusses bearing the barrel vault roof. The RE walls rise to 4.8 metres. The elements of the steel structure create equilibrium with the marked lines printed by the formwork on the RE walls. The project, while highly localised, offers an international example of the potential of cement stabilised RE in contemporary buildings.



Figure 7. Fremantle, O'Connor Transperth Bus Depot. Early 1990s. Courtesy of G. Hohnen.

In 1992 the introduction of bulk waterproofing and finishing for RE walls initiated the diffusion phase during the 1990s. This corresponded to the period of largest diffusion of RE in the south-west. The growing demand, the confident industry and further architectural research generated a new tradition of RE, creating a heritage of local buildings that illustrate the contemporary RE construction practice and the recent technological advancements.

The Ooi House (Fig. 8), designed by Kerry Hill, 1998, Margaret River, is comprised of two volumes placed alongside a connecting space left partially uncovered. The largest volume is framed in light steel and enclosed with transparent glass walls. This transparent volume has on one side a courtyard enclosed by a creamy-coloured RE wall. This free-standing RE wall visually connects with the private area of the house in RE, which is quite protected, with shadowed small openings. The RE volume is a monolith that is rooted to the ground, and changes with the light over the day. The two volumes are covered with a thin-profiled, and shallow, sloped corrugated iron roof. Compositionally, it is both a contemporary residence, and a quintessentially south-west Australian house. The texture of RE walls is an intrinsic aesthetic quality of the material, as it gives depth and plays with light. A RE building ages with the site and creates a universal sense of time.

The introduction of innovative materials, such as recycled bricks and recycled concrete, into the category of RE materials initiated the contemporary phase of research since the early 2000s. This was originated by a second generation of builders and architects, far more extended than the first. Cloister House, designed by Morq, 2017, Floreat (Perth Metropolitan area), with its béton-

brut aesthetic is a contemporary version of a RE building. It is an introspective composition of volumes that encloses a private space centred on the internal tropical courtyard.

Nowadays RE has become an ethical choice; it allows for the exploration of a contemporary architectural language addressing the environmental and sustainability issues, creating high-profile, deeply localised buildings rooted in the local culture and belonging to the native landscape. There is a new tradition of RE in Western Australia, emerging from decades of technical advancements and architectural studies; nonetheless, in several cases such deeply localised buildings intercede at an international level, contributing to define RE in contemporary architecture. The buildings mentioned here emerged from the personal research of Australian architects who have defined RE architecture as “contemporary”: firmly established and rooted in the local culture, and engaging with the design values of the contemporary living.



Figure 8. Ooi House 1998. Margaret River. Courtesy of Sean McGivern (Kerry Hill Architects).

Rammed Earth in Contemporary Architecture

Since the 1990s, contemporary RE architecture has appeared internationally. A diffuse consensus regarding the aesthetic and sustainability qualities of contemporary rammed earth emerged internationally in the 2000s. A number of different positions contributing to define how RE is used in contemporary architecture. RE can express the ethical intent of addressing environmental and sustainability issues in contemporary buildings, as in the case of Rauch’s RE wall in the lobby of the Feldkirch Region Hospital (1992, Feldkrich, Austria), Grieve Gillette and Cox Architects’ National Wine Centre (2001, Adelaide, South Australia), Rural Studio’s Mason’s Bend Community Centre (2000 Mason’s Bend, Alabama) and Renzo Piano’s Children’s Emergency Hospital (2018, Uganda). The Childrens’ Emergency Hospital synthesises the traditional idea of sustainable earth architecture, as the building essentially consists of massive rammed earth walls, and a thin canopy that support the PV field.

RE can create highly localised buildings that respond to the environmental context and are deeply integrated with the landscape, as demonstrated by Glenn Murcutt and Troppo Architects' Bowali Visitor Centre (1994, Northern Territory, Australia), Seth Stein Architects and Watson Architecture's Australian Equestrian Centre (2014 Melbourne, Victoria), Rick Joy's Tucson Mountain House, and Luigi Rosselli's the Great Wall of WA (2017, Pilbara, Western Australia). The Great Wall is essentially a zig-zag wall along the edge of sand dune that includes residences and facilities for local workers.⁴² The residences are therefore built hypogenously, with massive RE walls that contribute protecting the indoor environment from the harsh environment.

Contemporary RE architecture includes cultural and educational buildings, and represents certain aspects of related contemporary culture; it testifies to recent history, and expresses mutating forms of contemporary living. Those examples have a sense of history that embraces the past and involves the present, as evident in Rick Joy's Convent Avenue Studios (1995-1997, Tucson, Arizona), Rauch and Reitermann & Sessenroth's Chapel of Reconciliation (2000, Berlin, Germany), Marte's Chapel of Rest (2001 Batschuns, Austria), and Edition Office and Daniel Boyd's Aboriginal & Torres Strait Islander War Memorial (2018, Canberra, Australian Capital Territory). The Chapel of Reconciliation is comprised of an internal oval in RE encircled by timber louvre cladding. The use of RE here become a vehicle to address the building's outstanding cultural task: it was built for the 10th anniversary of the fall of the Berlin Wall on the site of a previous church that was taken down to free the firing line during the division of Germany.⁴³ The RE wall include fragments of the original building.⁴⁴ The lines of the plan of the original church are marked on the ground and the new construction is inserted on the choir of the original building.⁴⁵ Besides the commemoration of the history there is the awareness of the historical fact in future prospects.



Figure 9. Rick Joy Studio. Tucson Arizona. Photo Credit Santiago Perez. Courtesy of Santiago Perez.

Contemporary RE buildings may have a high technical profile emerging from a deep engagement of the architect with the materials and the craftsmanship-oriented making process and directed toward sustainability as in the case of Rick Joy's Studio at 400 Rubio Avenue (2000, Tucson, Arizona), Powell & Glenn Tarrawarra Museum of Art (2003 Healesville, Victoria, Australia), and Zumthor's Bruder Kaus (2007, Mechernich, Germany). Those buildings integrate RE with different construction materials and technologies and they present innovative technical solutions for several issues that were considered critical in traditional RE buildings. Joy's studio at 400 Rubio Avenue appears as a solid soil RE block, then a sequence of domestic spaces strings in between the indoor and the northward yard framing predisposed vistas of the sky. In the yard, a glass wall

faces the RE wall ending at the reflective surface of the pool.⁴⁶ Connections, junctions, and corners are emphasised by steel and refinement details. The highly refined materiality of the project results from the high level of quality control and the architect's thorough engagement with the materials and the craftsmanship-oriented construction process

Contemporary RE may be considered a versatile tool to generate diversified responses to contemporary architectural themes: the Oxaca School of Visual Art by Mauricio Rocha (2008, Oxaca, Mexico), Hotson Bakker Boniface Haden's Nk Desert Cultural Centre (2006, Osoyoos, Canada), and Kanutz Yeung Architecture's PAMS Healthcare Aboriginal Medical Service (2018, Western Australia) demonstrate a diversity of approaches. The PAMS⁴⁷ Healthcare Hub Newman, in Newman, east Pilbara, is a practical contribution to address the health and social issues that affect the communities. RE serves the purpose of connecting people and the country. Two volumes are built in RE, assembled around a courtyard and unified under the curved line of the roof, which is left partially open, allowing a native tree to rise and provide shadow. The RE walls incorporate the artworks of local artists representing the cultures of the local communities.

Conclusion

This study has investigated modern and contemporary uses of rammed earth. From the analysis of the Australian and international experiences in rammed earth, reasons have emerged for the use of rammed earth technology in contemporary architecture. However, such contemporary uses are historically related to the niche uses of RE during the first half of 1900s, that introduced essential technological enhancement and resulted in the definition of the first standards. The progressive inclusion of rammed earth in modern contexts, in Australia and USA, has created strategic precedents and let modern architects recognise the potential of the natural qualities of the material in terms of architectural design. Within the international contemporary scenario, the Western Australian experience occupies a remarkable place with a number of pioneers and crucial projects that interpret themes of global interest. There is a new tradition of RE in the south-west of Western Australia that derives from decades of technical and architectural research. This culture is still developing as demonstrated by the number of very recent RE projects of architectural and technological interest.

Endnotes

¹ The French term *Pisé* is often used to describe RE.

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³ Lewis, "The geography of earth building", 10.

⁴ Especially soils composition.

⁵ Collins, *Concrete the Vision of a new Architecture*.

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¹¹ Maria Luisa Germana', *Earth as a Building Material between Past and Future/ Terra Cruda nelle Costruzioni tra Passato e Futuro*, (Pisa: ETS Edizioni ETS, 2011).

- ¹² Kubler conceived history as a continuum sequences, where objects of human production appear as consequential answers to evolving problems. George Kubler, *The Shape of Time: Remarks on the History of Things*. (New Haven: Yale University Press, 1962).
- ¹³ Golebiowski, "Rammed earth".
- ¹⁴ Karl Ellington Karl, *Modern pisé-building: House-building with Compressed or Rammed Earth* (Bethany printing Company, 1924).
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- ²⁶ "Farrer Barn", Heritage NSW, accessed July 3, 2020, <https://www.heritage.nsw.gov.au/>
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- ³⁰ Lewis, "Pise' in Australia".
- ³¹ Alistair Knox, *Living in the Environment* (Mullaya Publication, 1975).
- ³² Knox, *Living*.
- ³³ Stephen Dobson, interview with the author, January 22, 2020. In Christmas 1975 Darwin was hit by a cyclone.
- ³⁴ Giles Hohnen, interview with the author, February 6, 2020.
- ³⁵ Giles Hohnen, interview with the author, February 6, 2020.
- ³⁶ Giles Hohnen, interview with the author, February 6, 2020.
- ³⁷ Giles Hohnen, interview with the author, February 6, 2020.
- ³⁸ Giles Hohnen, interview with the author, February 6, 2020.
- ³⁹ Giles Hohnen, interview with the author, February 6, 2020.
- ⁴⁰ Giles Hohnen, interview with the author, February 6, 2020.
- ⁴¹ At the beginning of the 1980s, in the south-west of WA, there were at least 14 specialised building services firm, capable to provide construction services for RE structures.
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