Modernist Concrete

Technologies of Brisbane church architecture in the 1960s

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Abstract

The reinforced concrete Holy Family Catholic church in Indooroopilly, designed by Douglas and Barnes between 1960 and 1963, was a milestone in in-situ concrete construction for Queensland (and possibly Australia). Influenced by international modern concrete church designs – most notably Marcel Breuer's St John's Abbey church, (1953-1961) and Oscar Niemeyer's chapel of the President's Palace (1958) – the team involved in the design, engineering and construction of Holy Family seized the opportunity to develop a building with expressive new forms, using new construction materials and methods, a combination never before tested in the State. Not surprisingly, the monumental and sculptural building repeatedly challenged its architects, engineers and builders. The separate baptistry chapel's jewelled crown of arches and slender spire, forced the architects to use complex mathematical formulae and geometries (tilted hyperbolic parabolas derived from conic sections) to prepare detailed drawings for the builders, who were already struggling to construct the church building's folded concrete walls and ceiling. One pleated bay at a time, they positioned double and single sided formwork, secured the reinforcing and concealed downpipes, poured concrete in sections into forms and also sprayed concrete in layers onto forms, waited for curing, before releasing the forms and repositioning to start the next pleat – a sequencing challenge of 'monumental' scale and unprecedented technical complexity. Due to these challenges, the church took more than two years to build and involved two construction contracts (after sending the first builder bankrupt). Fortunately, on two occasions when forms and a crane fell, workmen narrowly escaped injury and the building was unaffected. Based on interviews, archival and on-site research, this paper examines the design's conception and the buildings' realisation. Documenting the development of the Holy Family throughout its various phases, it seeks to understand how significant a milestone this church was for in-situ concrete construction in Australia.

Modern concrete churches

From the inter-war period on, church architects broke away from the nineteenth century's determination that Gothic was the architecture most fit for ecclesiastical buildings.[1] From the late nineteenth-century architects had increasingly used modern materials, like concrete, to harness the efficiencies of modern construction methods. Then in the inter-war years *avant garde* architects further used these methods, experimenting with expressive and geometric forms, as they sought modern architecture capable of evoking the sacred, like the Gothic had for its time. The church of Notre Dame Le Raincy (c.1923, France) designed by Auguste Perret (1874-1954) and the St. Englebert Catholic church (c.1932, Cologne-Riehl, Germany), designed by Dominikus Böhm (1880-1955) were globally recognised front-runners of modern reinforced concrete church design.[2] Post-war, Le Corbusier's (1887-1965) design for Chapelle Notre Dame du Haut in Ronchamp (c.1955, France)[3] had a very far-reaching architectural and artistic influence. A few years later, Marcel Breuer's (1902-1981) St John's Abbey church, (1953-1961, Collegeville, Minnesota USA), which he designed with the renowned Italian engineer Pier Luigi Nervi (1891-1979)[4] and Oscar Niemeyer's (1907-2012) chapel of St Francis of Assisi (c.1943, Brazil, Pampúlha) and chapel of the President's Palace (c.1958, Brazil, Brasilia) pushed the plasticity of concrete church architecture further.[5] Each of these churches were widely published and inspired many architects worldwide.[6]

In Australia architects began to experiment with concrete and new geometric forms from the early 1940s on. Most notable among these, is of course Jørn Utzon's (1918-2008) design for the Sydney Opera House (constructed 1959-73); and the Shine Dome in Canberra (c.1959) by Roy Grounds (1905-1981) for Grounds Romberg and Boyd.[7] In the 1950s Kevin Borland (1926-2000), Robin Boyd (1919-1971) and Peter McIntyre (b.1927) were also experimenting with Ctesiphon (sprayed concrete) construction to achieve parabolic structures.[8] In Brisbane, James Birrell's (b.1928) experiments with both in-situ and precast concrete created the curving forms of the Century Pool Complex (c.1959 Spring Hill), the geometric pattern panels of Wickham Terrace Car Park (constructed 1959-60, Spring Hill) and the textural zigzagging structure of Union College at the University of Queensland (built in stages between 1964 and 1974).[9]

Around the time that these buildings were realised, Australian church architecture began shifting away from Neo-Gothic and Romanesque architecture towards more modern variants, most frequently steel or concrete frames and brick cladding or infill panels. Notable exceptions to this general tendency included churches by Kevin Curtin (1925-1996). His St Bernard's Catholic church (c.1955, Botany, NSW) was most likely the earliest Australian

church to use an extruded parabolic arch cross-section for the length of the church, achieved with the combination of steel framing and precast.[10] In North Queensland Edwin (Eddie) Oribin (1927-2016) designed St Paul's Church of England (c.1959, Proserpine), using laminated timber and concrete portals to create an extruded parabolic form.[11] St Mary of the Sea Catholic Cathedral (c.1962, Darwin, NT, designed in 1957 by A. Ian Ferrier (1928-2000) of J.P. Donoghue, Cusick & Edwards) used reinforced concrete parabolic ribs expressed as the entry façade and within the interior.[12] Nervi's unbuilt 1957-61 scheme for the New Norcia Cathedral (WA) proposed multiple parabolic arches, arranging them as the three intersecting arches pitched tall over a triangular-planned cathedral.[13] Pleated pre-cast concrete was used by Loder and Dunphy for the street-facing, side elevation of St Andrews Presbyterian church (c.1960, demolished 2002, Gosford, NSW).[14] Gibbons and Gibbons used both precast and post-tensioned concrete shell construction (c.1961, Dee Why, NSW) and parabolic arches to create a highly expressive pleated and draped structure[15] - a design of similar size and an interesting comparison to Holy Family. Because of their innovativeness, all these designs were widely published. Nervi's scheme, in particular, received a great deal of attention. It was first announced in Australia by the Melbourne newspaper *The Age* in May 1959, immediately after receiving approval from Rome. Its realisation then seemed a certainty. The announcement suggested construction of the 'triangular ferro-concrete cathedral designed by the famous Italian engineer-architect Peri Luigi Nervi'[16] would commence as soon as August or September. Then in 1960 the scheme was showcased on the front cover and was the feature article in *Australian Architecture Today*.[17] The unrealised scheme for New Norcia

Figure 1. Western street approach; and Baptistery chapel
(State Library of Queensland, Royal Australian Institute of Architects, Photography Collection).

(lack of finances the likely reason),[18] was inspirational for Australia's architects; Rome's approval implying a permission for local church architects to use Nervi's material of choice, "ferro-cemento."[19]

Amidst the excitement generated by New Norcia's scheme, the reinforced, in-situ concrete Holy Family War Memorial Catholic church was designed in 1960-61[20] by William (Bill) Douglas (1930-2005)[21] and Harvey Blue (b.1938)[22] for the Brisbane-based practice Douglas and Barnes.[23] It was progressive for its modern geometric form, materiality and applied construction technology. Holy Family is, arguably, one of the earliest Australian examples of in-situ construction being used to realise a complex geometric design of angles and curves.[24] For Australian church architecture it is one of the most expressive, achieving the Catholic Church's design aspirations of immanence and transcendence[25] through its evocative form, tall volume and integrated modern artwork.[26] However, the liturgical movement's progressive ideas for liturgical renewal, formalised by the Catholic Church as part of Vatican Council II (1962-1965), are not evident in the design of Holy Family.[27] Instead Holy Family's vertical structural form and elongated basilica plan supports pre-conciliar attitudes.[28] Yet as had happened with its experimental ecclesiastic predecessors, local newspapers, Catholic publications and trade periodicals announced its arrival with pride, describing it as 'bold', 'striking', 'unusual and modernistic', 'most attractive' and even 'picturesque'.[29]

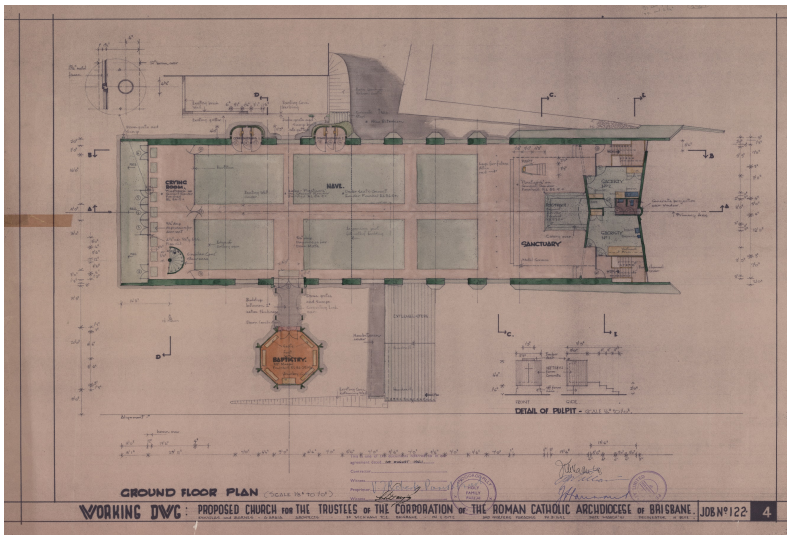

Figure 2. Floor Plan
(University of Queensland, Fryer Library Douglas & Barnes Collection, UQFL289 job0122).

Designing the Holy Family

Holy Family is one among a group of Douglas and Barnes' designs that use curved geometries to create local landmarks. Inspired by church architectures from abroad and interstate, they saw the potential of modern construction techniques, and experimented. Both their Southport Methodist church (designed 1959, opened 1964)[30] and their St George Presbyterian church (c.1968)[31] used parabolic geometry to create unique landmark roofs. At Southport, a 'twin parabolic-tiled roof'[32] is draped over a fan-shaped plan and mirrored along the length of the centre aisle the roof rises above the sanctuary to frame a large stained-glass feature window. Their St George Presbyterian church used parabolic geometry to create a roof that sweeps up to a point from the four sides of its square roof plan. Holy Family is, however, larger and more complex than these other churches. The time, the project brief and their skill sets aligned and they seized the opportunity to create a religious landmark building for their own city - Brisbane.

Douglas designed the 615-seat church building, but gave Blue (then a young architecture student)[33] the opportunity to design the baptistery chapel building. Blue subsequently drafted nearly all the projects construction drawings. Douglas prepared the specification and penned a couple of drawings.

The church building's monumental design has walls tilted at ten-degree off vertical, with origami-like pleats incorporated at high level along both sides that continue across the roof, a design which resembles the folded-plate structure of Breuer's St John's Abbey church. An imposing column-free concrete shell measuring 170-feet long by 47-feet wide (51.8m by 14.3m), and 57-feet 3-inches (17.5m) tall at its western end, Holy Family stood out within the pre-WWI residential suburbia,[34] and contrasted sharply with the former timber church it was built alongside of. Like its neo-gothic predecessors Holy Family's interior is grand, with its long nave, tall and narrow volume, and pleated ceiling. The worship space interior is approximately 33-feet 9-inches (10.3m) in height and 121-feet 4-inches by 43-feet (37m by 13) in plan.

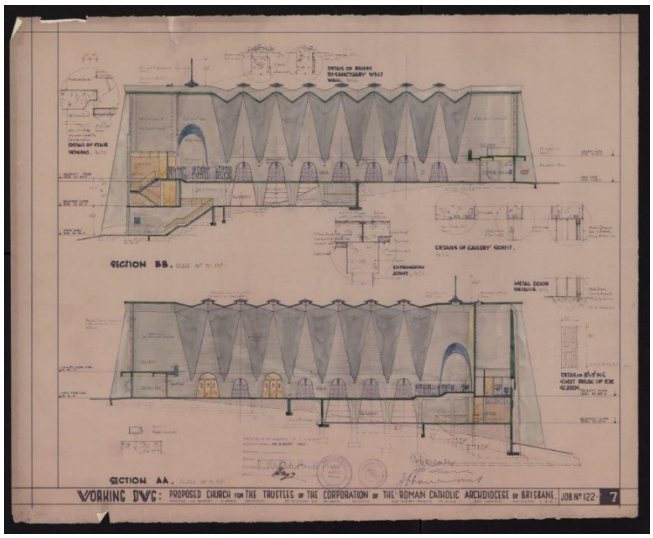

Figure 3. Interior; and Longitudinal building sections
(State Library of Queensland, Royal Australian Institute of Architects, Photography Collection; and University of Queensland, Fryer Library Douglas & Barnes Collection, UQFL289 job0122).

The baptistry chapel is octagonal in plan, with eight tilted hyperbolic parabola arches forming the walls. Sculptural curved pleats in the ceiling/roof connect the arched bays together, with a 40-foot (12.2m) slender and tapering spire taking the overall height to 65-feet (19.8m) and 90-feet (27.4m) above Central Avenue street level. The chapel is reminiscent of Böhm's St. Englebert Catholic church.[35]

The two structures are connected by an arched link, with arched openings along both sides. Also, a reinforced in-situ concrete structure, the link acts as a human scale device between the church and chapel's monumental forms. The confessionals bulging from the opposite side church curves added a curved organic geometry.

The design forced the architects to use complex mathematical formulae and geometries to prepare numerous detailed drawings for the builders.[36] For instance, the eight hyperbolic paraboloid arches of the baptistry chapel were calculated and set out using conic sections, with their ten-degree inward tilt adding a further factor of complexity to these calculations. Blue was very interested in mathematics and geometry, which Douglas recognised. Blue read the American periodical *Architectural Record,* which in the late 1950s and early 1960s had an 'Architectural Engineering' section in the back with technical articles, providing detail on both concrete shell construction and the use of mathematics in architecture.[37] The geometries and mathematics of regular solids and conic sections fascinated Blue, as did the work of the 1960 Royal Institute of British Architecture (RIBA) Gold Medal winner, Nervi, and Eero Saarinen's Chapel at Massachusetts Institute of Technology (MIT) with its outer cylinder walls, inner waving sin curve-like walls and the play of light within the space.[38]

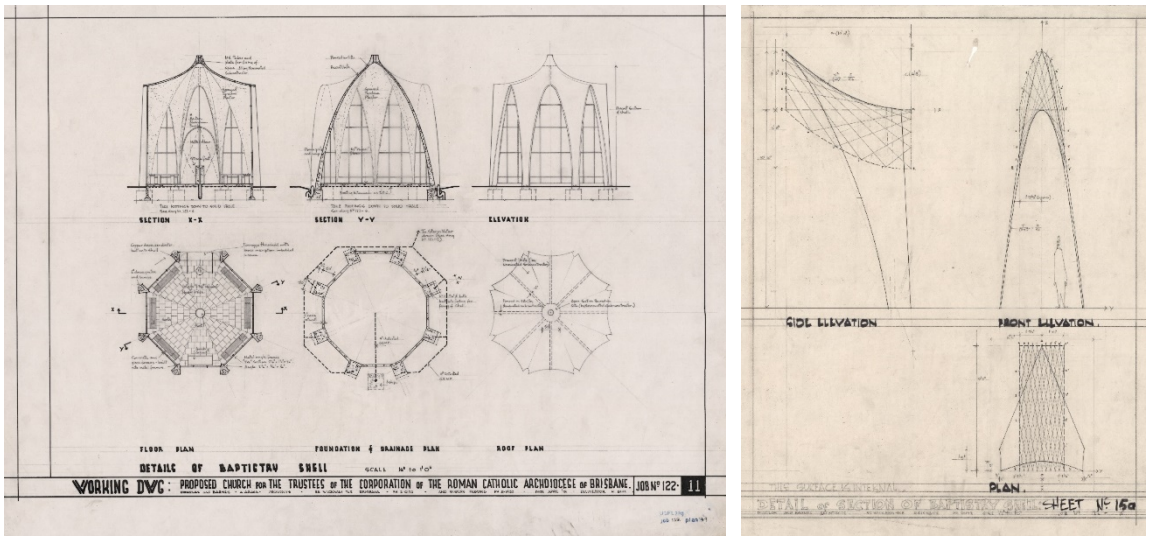

Figure 4. Baptistery Chapel Drawing & butter paper calculations
(University of Queensland, Fryer Library Douglas & Barnes Collection, UQFL289 job0122).

The building's realisation

The complex geometries and forms of Holy Family's design required a variety of concrete techniques and construction methods to be realised – slab on ground, suspended slab, post-tensioned waffle slab, tapered circular in-situ columns, tilting and vertical conventional double-formwork in-situ walls, single-form shotcrete wall and roof construction, on site pre-casting, spun-concrete and ferro-concrete. A progressive and knowledgeable structural engineer was required. R.J. McWilliam and Partners were commissioned for the project.[39] This practice was led by Russell John (Jack) McWilliam (1894-1991) and known for its concrete and steel capabilities. McWilliam's had considerable experience in engineering; he had also worked within the architectural practice of Hall and Prentice and lectured University of Queensland architectural students on construction. He was a member of the concrete structures code committee in the interwar years, and from 1946 a member (federal president in 1967) of the welding institute of Australia post-WWII.[40] This distinguished pedigree set him apart from his engineering peers. Working with McWilliam, Geoff Clarke (1928-2002) was the design engineer for the project.[41]

A challenging build, the church took more than two years to build and involved two construction contracts (bankruptcy necessitated the change of contractor). Pendus Pty Ltd won the tender with the lowest price and the contract was signed on 1 August 1961.[42] However, John D Booker Constructions Ltd took over the project and was recognised for completing the project.[43] Achieving the architects' design was a test for the builders, as non-

standard construction methods and locally untested techniques were extensively required. Within the architects' tender documentation some of the construction methods were specified in detail, and others were left to be resolved later,[44] or were adjusted in the process of working with the builder and his sub-contractors.[45] The project was to be completed in June 1962,[46] but took until November 1963. Costing more than £70,000,[47] it was not only one of the largest, but also one of the most costly Catholic churches to be built in Queensland post-war.[48]

The subfloor and main floor slab were constructed using conventional industry construction methods. However, as observed by *The Catholic Leader*, from the main floor slab up 'the method of construction was most unusual … instead of the building growing upwards, it grew longitudinally'.[49] The industry standard setup for scaffold was to surround the building envelope, but this was not possible with the walls tilting inwards. Instead the project's structural engineer designed a steel scaffold tower, which was produced by the builder. Supported on 'bogies'[50] – wheel sets used under train cars - and slid on rails down the centre of the building, 14-foot (4268mm) each move, the structure was referred to as the 'Jumbo and falsework'.[51] Interestingly, this approach resembles that used for tunnel construction and is not unlike one of the falsework methods that John Fitchen describes in his 1961 book *The Construction of Gothic Cathedrals.*[52] However, unlike the timber falsework used by Medieval builders and the sliding forms of tunnel construction, the engineer's design needed to enable the forms to be collapsed and lowered between slides, due to the inward folds of the pleats. To do so, the Jumbo supported a collapsible 'butterfly-like' formwork with hinges on winding jacks that pivoted from the top, and used a worm drive (a turning screw rod) to lift the formwork vertically up and down.[53] On two occasions the forms failed and a crane fell. Fortunately, workmen narrowly escaped injury and the building was unaffected. On the first of these occasions the formwork worm drive's rod screw failed, breaking along a weld join. A new one was made using a single piece of steel. This was at the beginning of the church's pleated wall and roof concrete works.

The complexity of the formwork, concreting and reinforcing was specifically highlighted in *The Queensland Master Builder*'s 1963 article, 'Bold Design Craftsman Built':

> Workmanship and detail in the formwork was of paramount importance in this off-the-forms finish … Externally the pleats, wide and deep at the top and tapering out at the bottom, called almost for moulds rather than formwork, and the variety and complexity of the reinforcement caused some difficulties in the construction.[54]

The walls and roof of the church are a combination of four and eight-inch (102 and 204mm) in-situ concrete. Double-forms were used for the vertical and ten-degree tilted wall sections (figure 5, left most detail, shown with a horizontal hatch pattern in elevation). Single-forms were positioned on the interior side of the wall pleats (no hatch pattern to this part of the same detail) and integral ceiling/roof.[55] Using this formwork, the church building was constructed from east to west,[56] with the eastern non-pleated walls and roof completed first, then one pleated bay at a time until all eight were done, finishing with western non-pleated walls and roof. As formwork was positioned for each pour, steel reinforcing was secured, concealed downpipes, conduits, bolts, and other attachments positioned for the later trades, ahead of concreting trade works. Complicating the construction sequencing further, the double-forms used a different concrete mix and a pouring method to the single-forms.

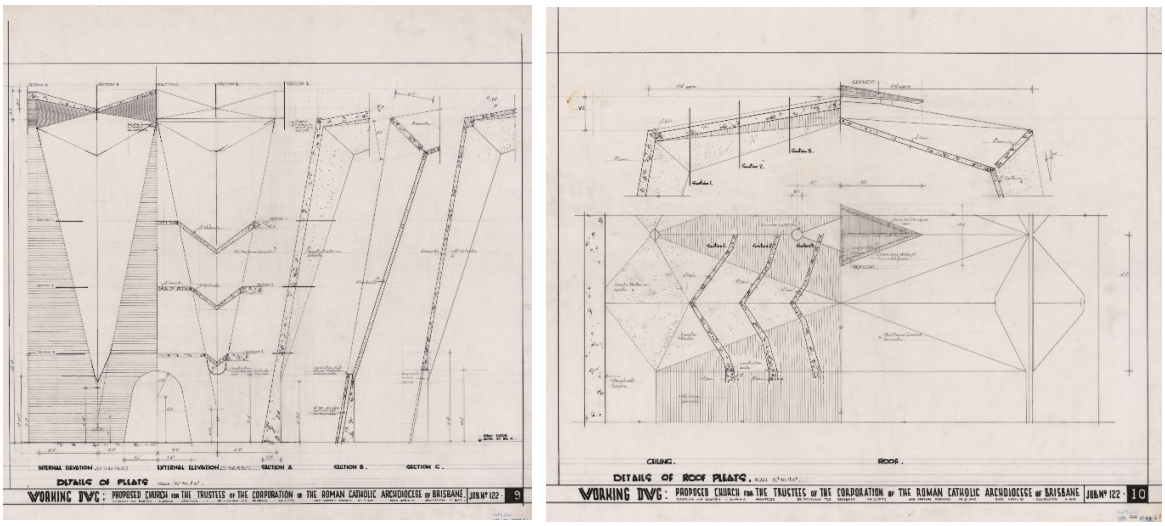

Figure 5. Pleated concrete wall and roof detail sheets
(University of Queensland, Fryer Library Douglas & Barnes Collection, UQFL289 job0122).

For the double-form wall sections a small hopper and light flexible drop chute were used to place the concrete mix in sections not exceeding 5-feet (1524mm) in height, which was then carefully vibrated.[57] It was this small hopper that caused the second construction accident towards the end of the project. It swung and hit the side of the jib crane. Not designed for sideways impact the crane fell. Blue recalls watching (from the other end of the site) as Douglas at pace descended (jumping almost 15-feet) from the top of the church's walls to run for safety. Douglas was surprised, though also relieved, that the crane driver overtook him as they and other workers ran up the hill for safety.[58]

The additional lean within the wall's pleats was deemed unsuited to double-forms by project's architects and engineers, due to the likelihood of the concrete slumping to the

interior form and causing the outer face to honeycomb. So, for the wall pleats and roof/ceiling single-forms, 'shotcrete',[59] a low-stump concrete mix was sprayed onto formwork in layers and whilst green the outer face was finished to an even plane.[60] The exterior wall forms were released after three days. However, it was not until after the concrete had cured (at least 28 days),[61] that the interior forms were released and lowered. Then with the Jumbo tower the forms slid along and repositioned for the next tilted and pleated wall section. The level of technical and constructability difficulty to achieve the acute origami-like triangular geometry, would have been immense, with various form types, complicated steel reinforcing, and alternating concrete mixes and pouring methods.

For the chapel, the contractor engaged a local boat builder to construct the formwork. Its complex curves were crafted using an 'adz', a broad bladed hoe with a short handle. The chapel's arched shell concrete walls and roof also used shotcrete, but were cast on the ground each as a column with a half-arch to each side,[62] cured and later the eight sections were raised and joined together – an early and highly crafted tilt-up construction method. The spire is spun-concrete, created by using techniques common for concrete light poles fabrication.[63] The spire was secured by pre-tensioned bolt connection to the chapel's apex, then all the chapel's concrete joints were concealed with sprayed concrete.[64]

Both the confessionals and the covered link were constructed using shotcrete, with the confessionals constructed as ferro-concrete, a method that sprays concrete to both sides of reinforcing covered in wire mesh.[65] The link used horizontal board forms installed to the outer face, the lines of these forms leaving a striped textural finish.

According to Blue, the architects 'were on tenterhooks' for much of the build,[66] concerned as to whether the concrete quality could and would continue to be achieved. The releasing of the baptistery chapels forms (arches and spire) were particularly stressful moments. Blue remembers the sense of relief when the forms came off to reveal both the shape and finish intact.[67]

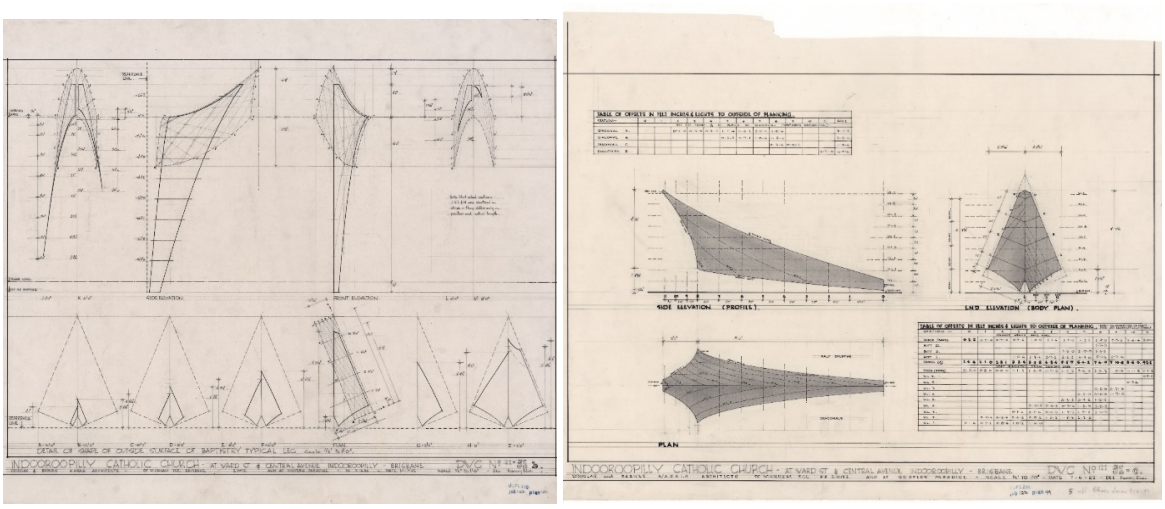

Figure 6. Setout for the outside shape of the Baptistry chapel
(University of Queensland, Fryer Library Douglas & Barnes Collection, UQFL289 job0122).

In the final construction phase, the buildings were coated externally and internally with 'Plastevic', a gloss vinyl paint,[68] which was boldly marketed as 'a liquid envelope … [providing] everlasting waterproofness.'[69] Blue also recalls the then general assumption - ignited by the lauded designs of Breuer, Niemeyer, Le Corbusier - that 'concrete once [constructed] could do all these things and last'.[70] The exterior was a very light shade of green vinyl paint,[71] except for the rendered and roughcast-stucco finished western facade wall, which was painted gold.[72] The worship space's pleated concrete wall and ceiling surfaces were sprayed in acoustic plaster, with finely ground stone additives.[73] When completed, the gloss and sparkle of the finishes would have been a sight to behold.

Conclusion

On 10 November 1963, Holy Family Catholic church was blessed and opened by Archbishop James Duhig (1871-1965; Archbishop 1917-65). He recognised the Parish Priest, Father Victor Francis Roberts (1904-1975, Indooroopilly PP 1938-1973),[74] with whom he had left the detail of the project, and spoke of his aspiration for Queensland's church buildings to be 'some of the finest specimens of architecture',[75] as Europe's church buildings are for architecture in Europe.[76] However, Duhig, perhaps 'diplomatically', chose not to describe the new building:

> I am not now going to enter into any commentary on this building, although what I might call its new features would tempt one to do so … there will no doubt be comment and criticism, for there are certain new features in the building that call for them, but that will pass.[77]

Not that long before, in 1959 while opening a new church in Tugun on the Gold Coast, Duhig spoke vehemently against modern architecture: 'it is about time we returned to dignified Goth'c & Romanesque arch'ture: modern ecclesiastical arch'ture is abominable'.[78] Maybe the basilica-type and landmark qualities of Holy Family aligned with Duhig's architectural ideals, even if (we speculate) the inherent structural expression of modernist concrete did not. Perhaps Duhig's restraint was due to his recognition of the herculean efforts that the parish community and construction team had just endured (fund raising and building).

A challenging design to document and build, Holy Family is still a landmark of monumental design today. It speaks of a time when church architecture aspired to be modern and express this in monumental complex forms. For Australia's church architecture, Holy Family played an experimental a role, it opened ideas of modern architecture. Yet, with the early 1960s Queensland Catholic Church only at the very cusp of liturgical renewal, Holy Family's worship space retained a conventional plan and a volume akin to the 'Gothic' spaces of its predecessors. Reinforced concrete was the new material of choice and technically challenging construction methods were necessary to achieve the architects' and parish priest's aspirations for 'new in design, old in tradition … [combining] beauty and dignity.'[79]

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Endnotes

[1] A determination led by Augustus Pugin (1812-52). Richard Hurley, *Irish Church Architecture in the era of Vatican II. (*Dublin: Dominican Publications, 2001), 4.
[2] Victoria M. Young, *Saint John's Abbey Church: Marcel Breuer and the Creation of a Modern Sacred Space*, (Minneapolis: University of Minnesota Press, 2014), 34-7.
[3] Visited by Blue in 1965, while travelled and visited architecture in Europe. (Harvey Desmond Crampton Blue, interviewed by Lisa Daunt (by phone), 17 April 2017).
[4] 'Published as early as 1954: 'A Benedictine monastery by By Marcel Breuer,' *Architectural Forum* 101 (July 1954), 148-155.
[5] Other designs by Eero Saarinen's (1910-1961), Enrique de la Mora (1907-1978), Felix Candela (1910-1997), Antonin Raymond (1888-1976) and Francis Barry Byrne's (1883-1967), were also significant advances in modern concrete and church design, pre-1960.

[6] Especially the American and English publications: *Architectural Record, Architectural Forum, Architectural Review*.
[7] Refer: Philip Goad, "Shells, spires and a dome: science and spirit in the space age." in Ann Stephen and Philp Goad, Andrew McNamara (eds), *Modern Times: the untold story of modernism in Australia*, (Carlton, VIC: Miegunyah Press, in association with Powerhouse publishing), 2008, 130-143.
[8] The Rice House (constructed 1953-4) designed by Boland in 1951; the Wood House and Supermarket designed by Boyd in 1952; and the Bellfield Community Centre designed by Borland and McIntyre in 1953. Refer to the Victorian Heritage Register listings H0123, and H1377.
[9] Macarthur, John, Deborah van der Plaat, Janina Gosseye, and Andrew Wilson (eds). *Hot Modernism: Queensland Architecture 1945-1975*. London: Artifice Books on architecture, 2015, 206-7, 274-5 and 156-7; and the Queensland Heritage Register listings 601240, 601511 and 602504.
[10] Cross-Section no.22 (August 1954); Cross-Section no.33 (July 1955); Architecture in Australia, (October-December 1955); Cross-Section no.39 (Jan 1956); Goad, 2008, 134.
[11] Martin J. Majer, *E.H. Oribin; the Work of a Far North Queensland Architect, (*Unpublished undergraduate thesis: University of Queensland, 1997); *Queensland Heritage Register,* listing 601589, https://environment.ehp.qld.gov.au/heritage-register/detail/?id=601589 accessed 27 September 2016.
[12] Geoffrey Douglas, 'St Monica's War Memorial Cathedral, Cairns', *The Twentieth Century Heritage Society of NSW Inc. The News*, (Spring 2012), 6-11; Fiona Joy Gardiner, Alice L.T.M. Hampson, *Interview with Ian Ferrier*, (St Lucia: May 30, 1999); Goad, 2008, 134.
[13] Annette Condello, 'Nervi and New Norcia: Italian Modernism in the Australia Outback,' 2012, http://www.arcduecitta.it/2012/07/magazine_nervi-and-new-norcia-italian-modernism-in-the-australian-outback-annette-condello/ accessed 13 December 2017.
[14] *Cross-Section*, no.95, (Sept 1960), 1; *Architecture in Australia,* (September 1960), 84-7
[15] *Architecture in Australia,* (September 1961), 100-102.
[16] 'Italian Design W.A. Cathedral', *The Age*, Melbourne, (Tuesday 26 May 1959), 4.
[17] "Australia's first Nervian structure", *Australian Architecture Today*, (June 1960), 12-16. The scheme was subsequently published "New Cathedral for New Norcia," *Building: Lighting: Engineering*, (July 1960), 25-26, 41; and aboard in England's *The Daily Telegraph* 'Abbey Arches in Concrete', (6 April 1960), then in both Italian and American periodicals.
[18] As speculated in Condello, 2012.
[19] *Building: Lighting: Engineering*, 1960, 41.
[20] Land purchased August 1960 (*The Catholic Leader*, (16 November 1916), 3); 1 August building contract signed (UQFL289 job#0122); 12 November 1961 Foundation stone (mounted at north side entry of building); 10 November 1963 blessed and opened (Erin Ahearn (compiled by), *Diamond Jubilee, Holy Family Parish, Indooroopilly: 1926-1986*, (Brisbane: Holy Family parish, 1986).
[21] Board of Architects of Queensland database, contacted 13 February 2018.
[22] Blue, 2017.
[23] 'In 1955 William (Bill) Leonard Douglas commenced private practice in Brisbane as William L. Douglas Architect and joined in partnership with Barry Barnes, as Douglas and Barnes, in Brisbane and the Gold Coast in 1957; until dissolution in 1972, when the practice returned to sole ownership of Bill Douglas.' (UQFL289 *Douglas, Daly and Bottger Collection*). Barnes ran the Gold Coast office and Douglas the Brisbane office.
[24] Most concrete buildings presented in compendia of Australian modern architecture (for example Jennifer Taylor's *Australian Architecture since 1960,* (Sydney: The Law Book Company Limited, 1986); and Harry Sowden (ed), *Towards an Australian Architecture,* (Sydney: Ure Smith Pty Ltd, 1968)) are square, structural forms, with the Sydney Opera House and the Shire Dome the examples of curving and non-square geometries.
[25] Immanence and Transcendence have been defined within Christian Theology. Immanence is the emergence of inherent or spiritual qualities. A church building should be immanent of faith, of belief and immanent of God. Transcendence is to go beyond the grasp of human experience. God is transcendent as he exists beyond the limitations and materiality of this earth. It is through immanence and transcendence that people worship together and have their own relationship with God. Thus, achieving both is what makes a church building sacred architecture and unique from its residential, secular and civic counterparts.
[26] Lisa Daunt, '1960s Brisbane Church Architecture: Creating modern, climatic and regional responses to liturgical change,' *Queensland Review 23.2. special Issue, 'Queensland Modernism,'* (December 2016) https://doi.org/10.1017/qre.2016.31

[27] While formalised by Vatican Council II, the need for liturgical renewal has a history dating back to the late 19th Century, the beginnings of the liturgical movement. Liturgical renewal led to significant architectural changes including: moving the alter forward, lowering the sanctuary, removing screens and altar rails, positioning the baptismal font within the main worship space and fanning the nave seating to gather the congregation around the sanctuary. Brisbane's first Catholic churches to address mid-twentieth century liturgical change were St Joachim's, Holland Park, opened 1961 (architect: P.J.L. Hanman); Our Lady Help of Christians, Hendra opened late 1961 (architect: Frank L. Cullen and Partners); and Our Lady of Dolours opened mid-1965 (architect: Frank Cullen, Fagg, Hargraves and Mooney).
[28] Pre-conciliar (pre-Vatican) and the attitude then was devotional individual worship (observing the priest), in comparison to post-Vatican Council II's liturgical change towards a church community that gathers to participate (with the priest) in worship.
[29] Including: *The Catholic Leader*, 'Striking Indooroopilly Church' (17 August 1961); 'Bold Design Craftsman Built', *The Queensland Master Builder* (August 15, 1963), 10-11; 'Three Chapels', *Building Ideas* (March 1964), 4; and *Architecture Building Engineering,* 'Modernistic church for Indooroopilly, (1 February 1964), 57.
[30] *Cross-Section* no.149, (1 March 1965), 2; UQ Fryer Library; SLQ Pictures Qld (RAIA photo collection); *Architecture in Australia,* (January-March 1959), 77; Visited by Lisa Daunt 20 October 2016.
[31] Douglas, Daly and Bottger UQFL289 job no.0328; and *History of St. Andrew's Presbyterian church, St. George*, unpublished, 2011, copy provided to Lisa Daunt 30 January 2018 by Victor Weber.
[32] Alice. L.T. Hampson, *The Fifties in Queensland: Why Not! Why?* (unpublished undergraduate thesis: University of Queensland, 1987), 215.
[33] Blue started working for Douglas and Barnes in 1960, married and graduated 1961, registered architect 1962, left for Europe in 1963 before Holy Family was completed on site (Blue, 2017).
[34] Indooroopilly, 6.5km from Brisbane City Hall, was then an established outer suburban suburb. The next suburbs (Chapel Hill and Kenmore) were subdivided and developed in the 1960s.
[35] When asked, Blue does not recall this building as a direct reference. (Blue, 2017).
[36] UQFL289 job 122. There are over 150 drawings in architectural construction set.
[37] Technical articles including: Seymour Howard, "Useful curves and curved surfaces: 31, 32, 33 – Hyperbolic Paraboloid" *Architectural Record* (June 1958), 215, 217, 219; Felix Candela, "Understanding the Hyperbolic Paraboloid" *Architectural Record* (July 1958), 191-5 and (August 1958), 205-7, 215; Seymour Howard, "Useful curves and curved surfaces: 19, 20 and 21 – Cones" *Architectural Record* (June 1957), 211, 213, 215.
[38] Blue, 2017.
[39] R.J McWilliams and Partners, becoming McWilliams Consulting Engineers, Qantec McWilliams, in 2007 they were acquired by Opus in 2010, which was acquired by WSP in 2017. (www.opus.com.au/assets/Uploads/PDFS/opus-Heritage-timelin.pdf accessed 16 December 2017)
[40] P.F. Clarke, 'McWilliam, Russel John (Jack) (1894-1991), Australian Dictionary or Biography, National Centre of Biography, Australian National University, http://abd.anu.edu.au/biography/mcwilliam-russell-john-jack-14656/text25791, published online 2014, accessed 16 December 2017; R.L. Whitmore, Geoffrey Cossins (eds), *Eminent Queensland Engineers,* vol.2 (Brisbane: Institution of Engineers, Australia, Queensland Division, 1999), 74-5; Donald Watson, Judith McKay, *A Directory of Queensland Architects to 1940*, (St Lucia: University of Queensland Library, 1984), 136.
[41] Email correspondence 18 January 2018 to Lisa Daunt, from Brian Wooldridge of Opus. No structural engineering drawings have been retained in archives. Email correspondence 1 and 9 February January 2018 from Peter Clarke (brother).
[42] UQFL289 job122 company seal used for the signed contract set and drafted sign board drawing 19, dated August 61.
[43] The building company listed in *Building Ideas,* (1964), 4; and *The Queensland Master Builder*, (1963), 10. It is unclear, from literature and archival review, when and how the main contractor changed. Blue speculates that it may be the same builder, re-named following financial restructure (Blue, 2017).
[44] For example, the baptistery chapel's construction was documented as a provisional sum, then clarified (in part) as a tender addendum (UQFL289 job122 Specification, 44 and 103)
[45] For example, the double-formwork was documented by the architects as timber (6" and 4" T.& G. boarding), to see the timber grain like seen in published European and American buildings. However,

during the tender phase the builder proposed 'acrow' formwork instead, this was accepted by Douglas and an addendum issued. (Specification, 25, 103; Blue, 2017)
[46] *The Catholic Leader*, (17 August 1961), 3.
[47] Over $19 Million in 2017 AU$ according to http://www.thomblake.com.au/secondary/hisdata/calculate.php
[48] Reported completed and furnished cost. The Catholic Leader, 'Archbishop Blesses Stone of New Indooroopilly Church', 16 November 1961, p.3; and '£3,750,000 has been spent on churches by the Archbishop,' *Catholic Leader*,14 November 1963.
[49] *The Catholic Leader*, (7 November 1963), 6.
[50] *The Queensland Master Builder*, (1963), 11.
[51] *The Catholic Leader*, (7 November 1963), 6; and *The Queensland Master Builder*, (1963), 11.
[52] John Fitchen, *The construction of Gothic cathedrals: a study of medieval vault erection*, (Oxford: Clarendon Press, 1961), 34-7.
[53] Harvey Blue, interviewed 31 October 2016 by Kaitlin Nichols (by phone); Blue 2017.
[54] *The Queensland Master Builder, (*1963), 11.
[55] Specification, 25.
[56] Blue 2016.
[57] With mechanical immersion vibrators - Specification, 29; Blue 2017.
[58] Blue 2017.
[59] 'Shotcrete' the generic product name used in the documentation, with 'Gunite' the brand name noted by Blue.
[60] Specification, 30-35, which on page 31 requires the works to 'be carried out in accordance with the Standard of the American Concrete Institute "Recommended Practice for the Application of Mortar by Pneumatic Pressure" (ACI 805 - 51).'
[61] Specification, 30.
[62] Blue, 2017; As detailed on the roof plan – see figure 4.
[63] Blue, 2016.
[64] *The Catholic Leader*, (7 November 1963), 6; *Building Ideas*, (1964), 4; and *The Queensland Master Builder, (*1963), 0.
[65] Specification, 43.
[66] Blue, 2017
[67] Blue, 2017
[68] Specification, 72-3. Made by Enamel Varnish and Chemical Co, of Blacktown, Sydney, and applied by S. and S.M. Broinawski, the Queensland Agents for 'Plastevic".
[69] Blue, 2017.
[70] Blue, 2017.
[71] Specification, 98; Blue, 2017.
[72] Specification, 98; *The Queensland Master Builder,* 1963, p.10.
[73] *The Queensland Master Builder,* 1963,10; Specification, 88.
[74] 'Crowd at Mass for Fr Victor Roberts, *The Leader,* (8 June 1975); Email correspondence 22 January 2018 to Lisa Daunt, from Carolyn Nolan, Catholic Brisbane Archdiocese Archives.
[75] *The Catholic Leader*, (14 November 1963), 6.
[76] *The Catholic Leader*, (14 November 1963), 6. Duhig's lack of comment, his building project expenditure and his greater aspirations for Queensland's church architecture were also the content of Brisbane's local newspaper, The Courier-Mail, (11 November 1963), 7; and later in Queensland's periodical *Architecture, Building, Engineering,* (1 February 1964), 57. A very consistent (Quoting nearly the same of Duhig's words) text was published across these papers.
[77] *The Catholic Leader*,14 November 1963, 6.
[78] The new Tugun Catholic Church was a 'neat, obviously cheap, unpretentious modern building' *Cross-Section*, no.80, (June 1959), 2.
[79] Fr Roberts quote in 'Challenging Design in New Edifice', *The Catholic Leader*, (14 November 1963), 6.