



**Politechnika Świętokrzyska**  
WYDZIAŁ BUDOWNICTWA I ARCHITEKTURY

Marek Barański

# KONSTRUKCJA I TECHNIKA BUDOWLANA STAROŻYTNEJ PALMYRY

BUILDING CONSTRUCTION  
TECHNIQUES IN ANCIENT PALMYRA



MONOGRAFIA

ARCHITEKTURA 10



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# Bibliografia

AAS/AAAS – Annales Archaeologiques Syriennes /Annales Archaeologiques Arabes Syrienne

DaM – Damaszener Mitteilungen

PAM – Polish Archaeology in the Mediterreanean

StP – Studia Palmyreńskie

## Abdul-Hak 1952

S. Abdul-Hak, L'Hypogee de Ta'ai a Palmyre, w: *AAS* 2/1952, s. 193–211

## Adam 1977

J. P. Adam, A propos du Trilithon de Baalbek: Le transport et la mise en oeuvre des mégalithes, w: *Syria* 54/1977, s. 31–63

## Adam 1984

J. P. Adam, *La Construction Romaine*, Paris 1984

## Adam 1994

J. P. Adam, *Roman Building. Materials & Techniques*, London 1994

## Adam 1966

S. Adam, *The Technique of Greek Sculpture*, Oxford 1966

## Addison 1838

Ch. Addison, *Damascus and Palmyra: A Journey to the East*, vol. II, London 1838

## Allag et al. 2000

C. Allag, N. Blanc, K. Parlasca, Palmyre: Stucs trouvés près de la source Efqa (site de l'Hotel Méridien), w: *Syria* 87/2010, s. 191–227

## Al Maqdissi 2000

M. Al Maqdissi, Note sur les sondages réalisés par Robert Du Mesnil Du Buisson dans la cour du sanctuaire de Bêl à Palmyre, w: *Syria* 77/2000, s. 137–158

## Amer, Gawlikowski 1985

Kh. Amer, M. Gawlikowski, Les sanctuaire impérial de Philippopolis, w: *DaM* 2/1985, s. 1–16

## Amy 1933

R. Amy, Premières Restaurations à L'Arc Monumental de Palmyre, w: *Syria* 14/1933, s. 396–411

## Amy, Seyrig 1936

R. Amy, H. Seyrig, Recherches dans la nécropole de Palmyre. L'hypogée de Iarhai, w: *Syria* 17/1936, s. 229–266

## Amy et al. 1962

R. Amy et al., *L'Arc d'Orange*, Paris 1962

**Amy 1976**

R. Amy, Remarques sur la construction du temple de Bêl, w: E. Frézouls (ed.) 1976, s. 53–68

**Anderson, Ousterhout 2016**

B. Anderson, R. Ousterhout, *Palmyra 1885. The Wolfe Expedition and the Photographs of John Henry Haynes*, London 2016

**Andronicos 1987**

M. Andronicos, Some reflections on the Macedonian tombs, w: *Annual of the British School at Athens*, vol. 82/1987, s. 1–16

**Andronicos 1993**

M. Andronicos, *Vergina. The Royal Tombs and the Ancient City*, Athens 1993

**Andrae, Lenzen 1933**

W. Andrae, H. Lenzen, Partherstadt Assur, w: *Vissenschaftliche Veröffentlichungen der Deutschen Orient Gesellschaft* 57, Leipzig 1933

**Arce 2003**

I. Arce, From the diaphragm arches to the ribbed vaults. An hypothesis for the birth and development of a building technique, w: S. Huerta (ed.), *Proceedings of the First International Congress on Construction History*, Madrid 2003, s. 225–241

**Arce 2006**

I. Arce, Umayyad Arches, Vaults and Domes: merging and Recreation. Contributions to Early Islamic Construction History, w: M. Dunkeld et al. (eds.), *Proceedings of the second International Congress on Construction History* (1–3 vol.), Cambridge 2006, vol. I, s. 195–220

**Arnaud 1982**

D. Arnaud, *Starożytny Bliski Wschód. Od wprowadzenia pisma do Aleksandra Wielkiego*, Warszawa 1982

**al-As'ad 1993**

Kh. (al-)As'ad, Palmyra in Islamicher Zeit, w: Ruprechtsberger (ed.) 1993, s. 360–364

**al-As'ad 1995**

Kh. al-As'ad, Restoration work at Palmyra, w: *ARAM* 7/1995, s. 9–17

**al-As'ad, Ruprechtsberger 1987**

Kh. al-As'ad, E. Ruprechtsberger, Palmyra in spätantiker, oströmischer (byzantinischer) und frühislamischer Zeit, w: Ruprechtsberger (ed.) 1987, s. 137–148

**al-As'ad, Stępniewski 1989**

Kh. al-As'ad, F. Stępniewski, The Umayyad Suq in Palmyra, w: *DaM* 4/1989, s. 205–223

**al-As'ad, Schmidt-Collinet 1995**

Kh. al-As'ad, A. Schmidt-Collinet, Ausblick, w: A. Schmidt-Collinet (ed.), *Palmyra – Kulturgegung im Grenzberich, Antite Welt, Sondernummer*, 1995

**al-As'ad 2013**

W. al-As'ad, Some tombs recently excavated in Palmyra, w: *StP* 12/2013, s. 15–24

**Asgari 1990**

N. Asgari, Objets de marbre finis, semi-finis et inachevés du Proconnèse, w: M. Waelkens (ed.), *Pierre eternelle du Nil au Rhin. Carrières et prefabrication*, Bruxelles 1990, s. 107–126

**Astengo 2016**

G. Astengo, The Rediscovery of Palmyra and its dissemination in Philosophical Transactions, w: *Notes and Records. The Royal Society Journal of the History of Science*, vol. 70/3/20, sept. 2016, s. 209–230

**Aurenche, Kozłowski 2013**

O. Aurenche, S.K. Kozłowski, Deux Polonais à Palmyre (avril 1926), w: *StP* 12/2013, s. 25–30

**Bacchetta, Bonardi 2010**

A. Bacchetta, I. Bonardi, L'edilizia residenziale della Siria romana: materiali, tecniche e sistemi costruttivi in Palestina fra Oriente e Occidente, w: *Meetings between Cultures in the Ancient Mediterranean. Proceedings of the XVII International Congress of Classical Archaeology (Rome 22nd-26th September 2008)*, *Bulletino di Archeologia on line*, volume speciale 2010, s. 12–33

**Barański 1983**

M. Barański, Udział Polaków w konserwacji zabytków Palmyry, w: *Ochrona Zabytków*, 1–2/1983, s. 82–89

**Barański 1985**

M. Barański, Palmyreńska konstrukcja płytowa – przyczynek do dziejów antycznego budownictwa, w: *Rocznik PP PKZ* 2/1985, s. 5–15

**Barański 1987**

M. Barański, Syryjska architektura antyczna – problem badań, w: *Rocznik PP PKZ* 1/1987, s. 615

**Barański 1988**

M. Barański, The Ruins of Palmyra: The problems of preservation, w: *Transactions (ASCHB)* 13/1988, s. 3–8

**Barański 1990**

M. Barański, The Colossal Order in the Near East, w: *Akten des XIII Internationalen Kongresses für Klassische Archäologie*, Berlin 1988, Mainz 1990, s. 358–359

**Barański 1991**

M. Barański, Opus Palmyrenum, w: *DaM* 5/1991, s. 379–384

**Barański 1992**

M. Barański, Remarks on the Near Eastern Colossal Order, w: S. Jakobielski, J. Karkowski (eds.), *50 Years of Polish Excavations in Egypt and the Near East, Acts of the Symposium at the Warsaw University 1986*, Warszawa 1992, s. 65–70

**Barański 1994**

M. Barański, The Roman Army in Palmyra: A case of adaptation of a pre-existing city, w: E. Dąbrowa (ed.) 1994, *The Roman and Byzantine Army in the East*, Kraków 1994, s. 9–17

**Barański 1995a**

M. Barański, The Great Colonnade of Palmyra, reconsidered, w: *Palmyra and the Aramaeans ARAM* 7/1995, s. 37–46

**Barański 1995b**

M. Barański Palmyra necropolis. The problem of preservation – Nekropole Palmyry. Problemy konserwacji – Les necropolis de Palmyre. Problemes de conservation, w: O. Czerner (ed.), *Cemetery Art – Sztuka cmentarna – L'art de cimetiere*, Wrocław 1995, s. 363–373

**Barański 1995c**

M. Barański, Building Techniques in Palmyra, w: *Studies in the History and Archaeology of Jordan*, 5/1995, s. 231–233

**Barański 1996**

M. Barański, Development of building techniques in Palmyra, w: *Palmyra and the Silk Road*, AAAS 42/1996, s. 379–384

**Barański 1997**

M. Barański, Western Aqueduct in Palmyra, w: *StP* 10/1997, s. 7–17

**Barański 2000**

M. Barański, The adoption of the arch structure in architecture of the Arabian Peninsula, w: *The Mandaeans, Antioch & Edessa & Cultural Interchange in the Arabian Peninsula*, ARAM 11–12/2000, s. 123–130

**Barański 2001**

M. Barański, Re-discovery of Palmyra, w: *(proceedings) International Millennium Congress “More than two thousand years in the history of architecture”*, vol. 2, sessions 3 and 6, Bethlehem 2001

**Barański 2004**

M. Barański, Romantyczna podróż Johanna Uphagena na Wschód, w: M. J. Sołtysik (ed.) *Kamienica w krajach Europy Północnej*, Gdańsk 2004, s. 215–236

**Barański 2013**

M. Barański, The First Archaeologist in Palmyra, w: *StP* 12/2013, s. 31–36

**Barański 2017a**

M. Barański, Damaged landscape of ancient Palmyra and its recovery, w: W. Kobylińska-Bunsch, Z. Kobyliński, L. D. Nebelsick (eds.), *Archaeologica Hereditas. Preventive conservation of human environment 6. “Architecture as an element of the landscape”*, Warszawa 2017, s. 47–55

**Barański 2017b**

M. Barański, Recovery of Palmyra Monuments, w: S. Giometti (red.), *Proceedings, Heritage for Planet Earth, “Smart Travel, Smart Architecture, Heritage and its Enjoyment for Dialogue”*, Florence 2017, s. 62–68

**Barański 2019**

M. Barański, Arch Construction in Palmyra (Syria), w: *Proceedings World Multidisciplinary Civil Engineering – Architecture – Urban Planning Symposium*, Prague 2018, online: Marek Baranski 2019 IOP Conf. Ser. Mat. Sci. Eng. 471 082012

**Barański in print**

M. Barański, The Monumental (corbeled) Arch of Palmyra, w: M. Gawlikowski, D. Wielgosz-Rondolino, M. Żuchowska (eds.), *Life in Palmyra. Life for Palmyra. Proceedings of the Conference in Memory of Khaled al-As'ad, 1934–2015*, Warszawa

**Bazaytova 2001**

R. Bazaytova, The Thracian Tombs – Study, Condition, Protection, w: (*proceedings*) *International Millenium Congress "More than two thousand years in the history of architecture"*, vol. 2, sessions 3 and 6, Bethlehem 2001

**Beaufort 1862**

E. A. Beaufort, *Egyptian Sepulchres and Syrian Shrines including some stay in the Lebanon, at palmyra, and the Western Turkey*, vol. I, London 1862

**Benjamin 1907**

Benjamin de Tudela, *Masa'ot Binyamin*, tl. M. N. Adler, *The Itinerary of Ben Jamin of Tudela*, London 1907

**Bernoville 1868**

R. Bernoville, *Dix Jours en Palmyrène*, Paris 1868

**Besenval 1984**

R. Besenval, *Technologie de la voûte dans l'Orient ancien*, vol. 1–2, Paris 1984

**Bessac 1988a**

J. C. Bessac, Influences de la conquête romaine sur le travail de la pierre en Gaule méditerranéenne, w: *Journal of Roman Archaeology* 1/1988, s. 57–72

**Bessac 1988b**

J. C. Bessac, Problems of identification and interpretation of tool marks on Ancient Marbles and Decorative Stones, w: Waelkens (ed.) 1988, s. 41–53, pl. 44–47

**Bieliński 1985**

P. Bieliński, *Starożytny Bliski Wschód. Od początku gospodarki rolniczej do wprowadzenia pisma*, Warszawa 1985

**Bieliński, Stępniewski (eds.) 2005**

P. Bieliński, F. Stępniewski (eds.), *Aux pays d'Allat. Mélanges offerts à Michał Gawlikowski*, Warszawa 2005

**Biran 1984**

A. Biran, The Triple-Ached Gate of Laish at Tel Dan, w: *Israel Exploration Journal*, 34/1984, s. 1–19

**Blake 1947**

M. E. Blake, *Ancient Roman Construction in Italy From the Prehistoric Period to Augustus*, Washington 1947

**Blake 1968**

M. E. Blake, *Roman Construction in Italy from Tiberius through the Flavians*, Washington 1968

**Borrmann 1904**

R. Borrmann, *Die Baukunst des Altertums und des Islam im Mittelalter. Geschichte der Baukunst*, Band 1, Leipzig 1904

**Bounni, Saliby 1965**

A. Bounni, N. Saliby, Six nouveaux emplacements fouillés à Palmyre (1963–1964), w: *AAAS* 15/1965, s. 124–138

**Bounni, Saliby 1968**

A. Bounni, N. Saliby, Fouilles de l'annexe de l'Agora à Palmyre, w: *AAAS* 18/1968, s. 93–102

**Bounni 1984**

A. Bounni, Palmyra – Oasen – Handelsstadt, w: K. Kohlmeyer, E. Strommenger (eds.), *Land des Baal. Syrien Forum der Völker und Kultur*, Mainz 1984

**Bounni, Seigne, Saliby 1992**

A. Bounni, J. Seigne, N. Saliby, *Le sanctuaire de Nabû à Palmyre, Planches*, Paris 1992

**Bounni 1999**

A. Bounni, Couronnement des sanctuaires du Proche-Orient Hellénistique et Romain: origine et développement du Merlon, w: *Topoi* 9 (2) 1999, s. 507–525

**Bounni 2004**

A. Bounni, *Le Sanctuaire de Nabû à Palmyre, Texte*, Beyrouth 2004

**Boyd 1978**

T. D. Boyd, The Arch and the vault in Greek Architecture, w: *American Journal of Archaeology* 82/1978, s. 83–100

**Brands 1991**

G. Brands, Anfänge und Nachleben Römischer Kreuzgewölbe, w: Hoffman et al. 1991, s. 29–38

**Brown 1845**

R. Brown, *Sacred Architecture, its rise, progress and present state*, London 1845

**Browning 1979**

I. Browning, *Palmyra*, Woolwich 1979

**Browning 2002**

I. Browning, *Petra*, London 2002

**Burford 1969**

A. Burford, *The Greek Temple Builders at Epidaurus*, Liverpool 1969

**Burns 2017**

R. Burns, *Origins of the Colonnaded Streets in the Cities of the Roman East*, Oxford 2017

**Burton, Tyrwhitt-Drake 1872**

R. F. Burton, C. F. Tyrwhitt-Drake, *Unexplored Syria. Visits to the Libanus, the Tulûl el Safâ, the Anti-Libanus, the Northern Libanus and the 'Allâh*, vol. I-II, London 1872

**Byliński 1995**

J. Byliński, A IIIrd Century Open Court Building in Palmyra. Excavation Report, w: *DaM* 8/1995, s. 213–246

**Cairolì 1991**

F. G. Cairolì, *L'edilizia nell'antichità*, Roma 1991

**Callot 1997**

O. Callot, La christianisation des sanctuaires romains de la Syrie du Nord, w: *Topoi*, 7/2, 1997, s. 735–750

**Cantineau 1933**

J. Cantineau, *Inventaire des Inscriptions de Palmyre, fasc. IX. Le sanctuaire de Bel*, Beyrouth 1933

**Cassas 1799**

L. F. Cassas, *Voyage pittoresque de la Syrie, dela Phénicie, de la Palestine et de la Basse Egypt*, I–III, Paris 1799

**Caton 2009**

Caton, *De Agricultura*, tł. I. Mikołajczyk, *O gospodarstwie rolnym*, Toruń 2009

**Champdor 1953**

A. Champdor, *Les ruines de Palmyre*, Paris 1953

**Choisy 1873**

A. Choisy, *L'art de bâtir chez les Romains*, Paris 1873

**Collart, Vicari 1969**

P. Collart, J. Vicari, *Le sanctuaire de Baalshamin à Palmyre*, vol. 1, Rom 1969

**Collart 1970**

P. Collart. Reconstruction du Thalamos du temple De Baalschamin à Palmyre, w: *Revue Archaeologique, Nouvelle Serie*, Fasc. 2/1970, 323–327

**Colledge 1976a**

M. A. R. Colledge. *The Art of Palmyra*, London 1976

**Colledge 1976b**

M. A. R. Colledge, Le Temple de Bel. Qui l'a fait, et pourquoi? w: Frézouls (ed.) 1976, s. 45–52

**Colledge 1977**

M. A. R. Colledge, *Parthian Art*, London 1977

**Coulton 1974**

J. J. Coulton, Lifting in Early Greek Architecture, w: *Journal of Hellenistic Studies* 94/1974, s. 1–19

**Coulton 1977**

J. J. Coulton, *Greek Architect at Work*, London 1977

**Cozzo 1928/1970**

G. Cozzo, *Ingegneria romana*, Roma 1928(1970)

**Crema 1959**

L. Crema, *L'architettura romana*, Torino 1959

**Crouch 1972**

D. Crouch, A Note on the Population and Area of Palmyra, w: *Mélanges de l'Université Saint Joseph* (Beyrouth) 47/1972, s. 241–250

**Crouch 1975a**

D. P. Crouch, Water System of Palmyra, w: *StP* 6–7/1975, s. 151–186

**Crouch 1975b**

D. P. Crouch, The ramparts of Palmyra, w: *StP* 6–7/1975, s. 6–44

**D'Angelo 2010**

B. D'Angelo, The Evolution of the Macedonian Tomb: Hellenistic Funerary Architecture Revisited, w: *Patrimoniun*. MK, year 3, no. 7–8, Skopje 2010, s. 57–68

**Daszkiewicz 1994**

M. Daszkiewicz, An Archaeometric Study of Ceramic and Clay Samples from Palmyra, w: *StP* 9/1994, s. 1–3

**Daszkiewicz (et al.) 1995**

M. Daszkiewicz, M. Krogulska, J. Raabe, Technology and Typology of Common-Ware Pottery from Palmyra, w: H. Meyza, J. Mlynarczyk (eds.), *Hellenistic and Roman Pottery in the Eastern Mediterranean – Advances in Scientific Studies, Acts of the II Nieborów Pottery Workshop, Nieborów, 18–20 December 1993*, Warszawa 1995, s. 41–59

**Daszkiewicz (et al.) 2000**

M. Daszkiewicz, M. Krogulska, E. Bobryk. Composition and Technology of Roman Brittle Ware Pottery from a Kiln Site in Palmyra (Syria), w: *ReiCret Acta* 36/2000, s. 537–548

**Degeorge 2001**

G. Degeorge, *Palmyra, métropole caravanière*, Paris 2001

**Delplace 2005**

C. Delplace, Quelques remarques sur les “salles de banquets” à Palmyre, w: Bieliński, Stępnowski (eds.) 2005, s. 43–52

**Delplace, Dentzer-Feydy 2005**

C. Delplace, J. Dentzer-Feydy, *L’Agora de Palmyre*, Bordeaux – Beyrouth, 2005

**Dentzer, Blanc 1995**

J. M. Dentzer, P. M. Blanc, Monuments nabateens de Bostra: Matériaux et techniques de construction et de revêtement, w: *Studies in the History and Archaeology of Jordan*, 5/1995, s. 223–230

**Dipasquale, Mecca (eds.) 2009**

L. Dipasquale, S. Mecca (eds.), *Earthen domes and habitats. Villages of Northern Syria. An architectural tradition shared by East and West*, Pisa 2009

**Dodge 1988a**

H. Dodge, Palmyra and the Roman Marble Trade: Evidence from the Baths of Diocletian, w: *Levant*, 20/1988, s. 215–230

**Dodge 1988b**

H. Dodge, Decorative Stones for architecture in the Roman Empire, w: *Oxford Journal of Archaeology*, 7, 1/1988, s. 65–80

**Dodge 1990**

H. Dodge, The Architectural Impact of Rome in the East, w: M. Henning (ed.), *Architecture and Architectural Sculpture in the Roman Empire*, Oxford 1990, s. 108–120

**Durm 1885/1905**

J. Durm, *Hanbuch der Architektur, Zweiter Teil: Die Baustile. Historische und Technische Entwicklung, Band 2. Die Baukunst der Etrusker, Die Baukunst der Römer*, Darmstadt 1885/Stuttgart 1905

**Duru 1976**

R. Duru, Techniques de construction orientales (à propos du temple de Bêl), w: Frèzouls (ed.) 1976, s. 69–74

**Dworakowska 1975**

A. Dworakowska, Wydobywanie i obróbka kamienia, w: K. Majewski (ed.), *Kultura materialna starożytnej Grecji. Zarys*, vol. 1, Wrocław 1975, s. 15–118

**Edwell 2008**

P. M. Edwell. *Between Rome and Persia. The middle Euphrates, Mesopotamia and Palmyra under Roman control*, Routledge 2008

**Encyclopedie 1751–1772**

M. Diderot, M. d'Alembert, *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, par une société des gens des lettres*. t. I–XXVIII, Paris 1751–1772

**Eristov, Blanc, Allag 2009**

H. Eristov, N. Blanc, C. Allag, *Les stucs trouvés près de la source Efqa à Palmyre*, Damas 2009

**Erlach 1725**

F. von Erlach, *Entwurf einer Historischen Architectur*, Leipzig 1725

**Fellmann 1970**

R. Fellmann, *Le sanctuaire de Baalshamin à Palmyre*, vol. 5, *Die Grabanlage*, Roma 1970

**Fellmann 1987**

R. Fellmann, Der Palast der Königin Zenobia, w: E. Ruprechtsberger (ed.), *Palmyra. Geschichte, Kunst und Kultur der Syrischen Oasenstadt*, Linz 1987, s. 131–136

**Fiema 1986**

Z. Fiema, An Inscription from the Temple of Bel in Palmyra Reconsidered, w: *Bulletin of the American Schools of Oriental Research* 263/1986, s. 81–83

**Filarska 1967**

B. Filarska, Studia nad dekoracjami architektonicznymi Palmyry, w: *StP* 2/1967

**Foliot 1990**

Ph. Foliot, Louis Vignes and Henry Sauvaire, photographers on the expeditions of the Duc de Luynes, w: *History of Photography* 14/1990, 233–250

**Forbes 1964**

R. J. Forbes, *Studies in Ancient Technology*, vol. 1–9, Leiden 1964

**Fourdrin 2009**

J. P. Fourdrin, Le front de scène du théâtre de Palmyre, w: *Fronts de scène et lieux de culte dans le théâtre antique*, w: *Maison de l'Orient et de la Méditerranée Jean Poilloux (Travaux de la maison de l'Orient et de la Méditerranée)*, no 52, 2009, s. 189–233

**Freyberger 1998**

K. S. Freyberger, *Die frühkaiserzeitlichen Heiligtümer der Karawanenstationen im hellenisierten Osten*, Mainz 1998

**Frézouls (ed.) 1976**

E. Frézouls (ed.), Palmyre. Bilan et perspectives, Colloque de Strasbourg 1973, w: *Ktema* 1/1976

**Frézouls 1976**

E. Frézouls, A propos de l'architecture domestique à Palmyre, w: Frézouls (ed.) 1976, s. 29–52

**Gabriel 1926**

A. Gabriel, Recherches archéologiques à Palmyre, w: *Syria* 7/1926, s. 71–92

**Gajdukiewicz 1981**

B. Gajdukiewicz, *Bosporskije goroda*, Leningrad 1981

**Gallor, Waliszewski (eds.) 2007**

K. Gallor, T. Waliszewski (eds.), *From Antioch to Alexandria. Recent studies in Domestic Architecture*, Warszawa 2007

**Gatier, Seigne 2015**

P. L. Gatier, J. Seigne, Un exceptionnel document d'architecture à Gerasa (Jerash, Jordanie), w: *Syria* 92/2015, s. 263–277

**Gavin 1982**

C. E. S. Gavin, *The Image of the East: Photographs by Bonfils*, Chicago 1982

**Gawlikowska 1975**

K. Gawlikowska, *Sztuka Mezopotamii*, Warszawa 1975

**Gawlikowska 2010**

K. Gawlikowska, Ruiny Palmyry oczyma dawnych podróżników, w: M. Gawlikowski, *Palmyra*, Warszawa 2010, s. 79–120

**Gawlikowski 1970**

M. Gawlikowski, *Monuments funéraires de Palmyre*, Warszawa 1970

**Gawlikowski 1973**

M. Gawlikowski, *Palmyre 6, Le temple palmyrénien*, Warszawa 1973

**Gawlikowski 1974**

M. Gawlikowski, Les défences de Palmyre, w: *Syria* 51/1974, s. 231–242

**Gawlikowski 1976**

M. Gawlikowski, *Sztuka Syrii*, Warszawa 1976

**Gawlikowski 1977**

M. Gawlikowski, La temple d'Allat à Palmyre, w: *Revue Archeologique* 2/1977, s. 253–274

**Gawlikowski 1984**

M. Gawlikowski 1984, *Palmyre 8, Les Principia de Diocletien, "Temple des Enseignes"*, Warszawa 1984

**Gawlikowski 1985**

M. Gawlikowski, Świątynia Allat w Palmyrze. Wstępny raport z wykopalisk 1974–1976, w: *StP* 8/1985, s. 5–25

**Gawlikowski 1990a**

M. Gawlikowski, La premier temple d'Allat, w: P. Matthiae, M. N. van Loon, H. Weiss (ed.), *Resurrecting the Past. A Joint Tribute to Adnan Bounni, PIHANS*, vol. 67, Leyden 1990

**Gawlikowski 1990b**

M. Gawlikowski, Palmyra w: *PAM I. Reports 1988–1989, 1990*, s. 37–44

**Gawlikowski 1991**

M. Gawlikowski, Palmyra w: *PAM II. Reports 1989–1990, 1991*, s. 85–90

**Gawlikowski 1992**

M. Gawlikowski, Palmyra 1981–1987, w: *Etudes et Travaux* XVI/1992, s. 325–335

**Gawlikowski 1993a**

M. Gawlikowski, Rapports des missions actives à Palmyre 1990–1991, w: *Syria* 70/1993, s. 561–567

**Gawlikowski 1993b**

M. Gawlikowski, Eine Nuentdeckte Früchristliche Kirche in Palmyra, w: Rupreschsberger (ed.) 1993, s. 150–157

**Gawlikowski 1996**

M. Gawlikowski, Palmyra: Excavations 1995, w: *PAM* 7/1996, s. 139–146

**Gawlikowski 2000**

M. Gawlikowski, Palmyra Season 1999, w: *PAM* 11/2000, s. 249–260

**Gawlikowski 2001**

M. Gawlikowski, Palmyra bizantyjska. Miasto i jego katedra, w: B. Iwaszkiewicz-Wronikowska, D. Próchnik (eds.), *Sympozja Kazimierskie poświęcone kulturze późnego antyku i wczesnego chrześcijaństwa II*, Lublin 2001, s. 187–195

**Gawlikowski 2007**

M. Gawlikowski, Beyond the Colonnades: Domestic Architecture in Palmyra, w: Gallor-Waliszewski (eds.) 2007, s. 79–93

**Gawlikowski 2008**

M. Gawlikowski, Palmyra in Early Islamic times, w: K. Bartl, A. Moaz (eds.), *Residences, Castles, Settlements. Transformation Process from the Late Antiquity to Early Islam in Bilad al Sham. Proceedings of the International Conference Held in Damascus, November 2006 – Orient Archäologie* vol. 24/2008, Rahden, s. 89–96

**Gawlikowski 2010**

M. Gawlikowski, *Palmyra*, Warszawa 2010

**Gawlikowski 2014**

M. Gawlikowski, Palmyre: reexcavating the site of the Tariff (fieldwork in 2010–2011), w: *PAM* 23/1 (Research 2011)/2014, s. 415–430

**Gawlikowski 2016**

M. Gawlikowski, The Urban Development of Palmyra, w: *ARAM* 28, vol. 2/2016, s. 485–496

**Gawlikowski 2017**

M. Gawlikowski, *La sanctuaire d'Allat à Palmyre*, Warszawa 2017

**Gawlikowski 2018**

M. Gawlikowski, The Indian Trade between the Gulf and the Red Sea, w: *PAM* 26/2 Studies/2018, s. 15–31

**Gawlikowski, Żuchowska 2010**

M. Gawlikowski, M. Żuchowska, La mosaique de Bellerophon, w: *StP* 11/2010, s. 9–42

**Gawlikowski, Wielgosz-Rondolino, Żuchowska (eds.) in print**

M. Gawlikowski, D. Wielgosz-Rondolino, M. Żuchowska (eds.), *Life in Palmyra, Life for Palmyra. Proceedings of the Conference in Memory of Khaled al-As'ad, 1934–2015*, Warszawa, in print

**Gąssowska 1982**

A. Gąssowska, Maternus Cynegius. Praefectus Praetorio Orientis and the destruction of the Allat Temple in Palmyra, w: *Archeologia* 33/1982, s. 107–123

**Genequand 2008**

D. Genequand, An Early Islamic Mosque in Palmyra, w: *Levant*, 40, no. 1/2008, s. 3–15

**Genequand 2013**

D. Genequand, De Rome à l'Islam: recherches récentes sur le dit “Caesareum” de Palmyre, w: *StP* 12/2013, s. 97–114

**Giuliani 1991**

C. F. Giuliani, *L'edilizia nell'antichità*, Rome 1991

**Grassi, Zenoni, Rosii 2012**

M. T. Grassi, G. Zenoni, G. Rosii, Tecniche e materiali dell'architectura palmirena: il caso dell' Edificio con Peristilio del quartiere Sud-Ouest (PALM.A.I.S. scavi 2008–2010), w: M. P. Bologna, M. Ornaghi (eds.), *Novissima Studia. Dieci anni di antichistica Milanese. Atti dei Seminari di Dipartimento 2011, Quaderni di Acme* 129, Milano 2012, s. 53–82

**Grassi, al-As'ad 2013**

M. T. Grassi, W. al-As'ad, PAL.M.A.I.S. recherches et fouilles d'une nouvelle Mission conjointe syro-italienne dans le quartier sud-ouest de Palmyre, w: *StP* 12/2013, s. 115–128

**Ghirshman 1962**

R. Ghirshman, *Iran, Parthes et Sasanides*, Paris 1962

**Haddad 2015**

N. A. Haddad, Critical Assessment of the Barrel Vault Geometrical and Structure of the Oldest Macedonian Tomb of Eurydice in Vergina, w: *Mediterranean Archaeology and Archaeometry*, 15, no. 2/2015, s. 143–162

**Halifax 1695**

W. Halifax, A relation of a Voyage from Aleppo to Palmyra in Syria, sent by the Revernd W. Halifax, w: *Philosophical Transactions* no. 217/ Oct. 1695, s. 83–100

**Halifax "An extract" 1695**

An extract of the Journals of two several voyages of English merchants of the factory of Aleppo to Tadmor anciently called Palmyra, w: *Philosophical Transactions* no. 218/ Nov.–Dec. 1695, s. 129–160

**Hamblin, Seely 2007**

W. J. Hamblin, D. R. Seely, *Solomon's Temple. Myth and History*, London 2007

**Hammad 2013**

M. Hammad, Morphologie des environs de Palmyre: relief, enceintes, pistes, w: *StP* 12/2013, s. 129–148

**Hammond 1995**

Ph. Hammond, Nabataean Architectural Technology, in: *Studies in the History and Archaeology of Jordan*, 5/1995, s. 215–221

**Hannavy 2008**

J. Hannavy, *Encyclopedia of the Nineteenth-Century Photography*, vol. 1, New York 2008

**Hansen 1991**

E. Hansen, Versetzen von Baugliedern am Griechische Tempel, w: Hoffman et al. (eds.) 1991, s. 72–79

**Hekster, Kaizer 2004**

O. Hekster, T. Kaizer, Mark Antony and the Raid on Palmyra: Reflections on Appian "Bella Civillia" vol. 9, w: *Latomus* 63.1/2004, s. 70–80

**Henning 2013**

A. Henning, Die Turmgräber von Palmyra. Eine locale Bauform in kaiserzeitlichen Syrien als Ausdruck Kultureller Identität, Orient Archäologie, Bd. 2, Köln 2013

**Heron 1894**

Heron, *Mechanica*, tl. Carra de Vaux, *les Mechaniques au l'Elevateur de Heron d'Alexandrie*, Paris, Leroux 1894

**Higuchi, Saito 2001**

T. Higuchi, K. Saito, *Tomb F. Tomb of BWLH and BWPP Southeast Necropolis in Palmyra*. Research Center for Silk Roadology vol. 2, Nara 2001

**Hodge 1960**

A. T. Hodge, *The Woodwork of Greek Roofs*, Cambridge 1960

**Hoffmann (et al.) 1991**

A. Hoffmann, E. L. Schwandner, W. Hoepfner, G. Brands, (eds.), *Bautechnik der Antike*, Mainz 1991

**de Hond 1997**

J. de Hond, Treffelyke ruinen en overblyfzelen Bejschrijving van Palmyra, w: J.W. Drijvers, J. de Hond, H. Sancisi-Weerdenburg (eds.), *Ik Hadde de Nieusgierigheid. De reizen door het nabije Oosten van Cornelius de Bruijn*, Leiden 1997, s. 111–128

**Ingholt 1935**

H. Ingholt, Five dated tombs from Palmyra, w: *Berytus* 2/1935, s. 57–120

**Ingholt 1936**

H. Ingholt, Inscriptions and Sculptures from Palmyra I, w: *Berytus* 3/1936, s. 83–126

**Intagliata 2018**

E. Intagliata, *Palmyra after Zenobia 273–750. An Archaeological and Historical Reappraisal*, Oxford 2018

**Jabłońska-Szyszko, Rudnicka 1988**

M. Jabłońska-Szyszko, B. Rudnicka, Study of the Reasons for the Destruction of Antique Building Stone in Palmyra, w: I. Ciabach (ed.), *Proceedings, VIth International Congress on Deterioration and Conservation of Stone*, Toruń 1988, s. 207–215

**Jaczynowska 1995**

M. Jaczynowska, *Dzieje Imperium Romanum*, Warszawa 1995

**Jagher, Tensorer 2011**

R. Jagher, J. M. Tensorer, El Kow, a Key Area for the Palaolithic of Levant in Central Syria, w: J. M. Tensorer, R. Jagher, M. Otte (eds.), *The Lower and Middle Palaeolithic in the Middle East and Neighbouring Regions*, ERAUL 126/2011, s. 197–208

**Jakubiak 2014**

K. Jakubiak, Sacral landscape in Hatra, w: *Światowit, suppl. Series A: Antiquity*, Warszawa 2014

**Jastrzębowska 2013**

E. Jastrzębowska, La christianisation de Palmyre: l'exemple du temple de Bel, w: *StP* 12/2013, s. 177–191

**Jong 2017**

L. de Jong, *The Archaeology of Death in Roman Syria. Burial, Commemoration and Empire*, Cambridge 2017

**Josephi 1979**

Josephi Flavii, *Antiquitates Iudaicae*, tł. Z. Kubiak, J. Radożycki, Józef Flawiusz, *Dawne Dzieje Izraela*, Poznań 1979

**Josephi 1981**

Josephi Flavii, *Bellum Iudaicum*, tł. J. Radożycki, *Wojna żydowska*, Warszawa 1991

**Juchniewicz, al-As'ad, Hariri 2010**

K. Juchniewicz, Kh. al-As'ad, Kh. Hariri, The defence wall in Palmyra after recent Syrian excavations, w: *StP* 11/2010, s. 55–73

**Juchniewicz 2013**

K. Juchniewicz, Late Roman fortifications in Palmyra, w: *StP* 12/2013, s. 193–203

**Juchniewicz, Żuchowska 2013**

K. Juchniewicz, M. Żuchowska, Remarks on water supply in Palmyra. Results of a survey in 2010, w: *PAM* 22 (season 2010)/2013, s. 341–350

**Jundrowsky 2015**

R. Jundrowsky, *Kamieniarstwo, współczesne spojrzenie na tradycję*, Warszawa 2015

**Kader 1996**

I. Kader, *Propylon und Bogentor. Untersuchungen zum Teträpylon von Latakia und anderen frühkaiserzeitlichen Bogenmonumenten in Nahen Osten*, Mainz 1996

**Kalayan 1968**

H. Kalayan, A New outlook into the history of architecture through the tools used as schools of masonry, w: *Al Mouhandess* no. 11/April 1968, Beyrouth, s. 4–15

**Kalayan 1971**

H. Kalayan, Notes on assembly marks, drawings and models concerning the Roman period monuments in Lebanon, w: *AAAS*, XXI/1971, s. 69–273

**Kawami 1982**

T. S. Kawami, Parthian Brick Vaults in Mesopotamia, w: *Journal of Ancient Near Eastern Studies* 14/1982, s. 61–67

**Kennedy 1996**

D. Kennedy, Syria, w: A. Bowman (ed.), *The Cambridge Ancient History*, vol. X, *The Augustean Empire 43 B.C. – A.D. 69*, Cambridge 1996, s. 703–736

**Klengel 1986**

H. Klengel, *Syrien zwischen Alexander un Mohammed. Denkmale aus Antike und fruhem Christentum*, Leipzig 1986

**Kohlmeyer, Strommenger 1982**

K. Kohlmeyer, E. Strommenger (eds.), *Land des Baal. Syrien – Forum der Volker und Kulturen*, Mainz 1982

**Koldewey 1914**

R. Koldewey, *The Excavations at Babylon*, London 1914

**Koss 2004**

I. Koss, *Badanie próbek skalnych oraz zapraw pobranych w Palmyrze, Syria w czasie sezonu wykopaliskowego 2002/2003*, Warszawa 2004, mps. Archiwum Polska Stacji Archeologii Śródziemnomorskiej UW

**Kotula 2006**

T. Kotula, *Aurelian i Zenobia*, Wrocław 2006

**Kowalski 1994**

S. Kowalski, The Praetorium of the Camp of Diocletian in Palmyra, w: *StP* 9/1994, s. 39–70

**Kowalski 1996**

S. Kowalski, Doubtful Christian reutilization of the Baalshamin Temple in Palmyra, w: *DaM* 9/1996, s. 217–226

**Kraeling 1937**

C. H. Kraeling, *Gerasa. City of the Decapolis*, New Haven, 1937

**Kraeling 1961/1962**

C. H. Kraeling, Color Photographs of the paintings of the Tomb of the Three Brothers in Palmyra, w: *AAS*, 11–12/1961–1962, s. 13–18

**Krogulska 1984**

M. Krogulska, Le Forum, w: M. Gawlikowski: *Palmyre 8, Les Principia de Diocletien, "Temple des Enseignes"*, Warszawa 1984, s. 70–91

**Krogulska 1985**

M. Krogulska, Ceramic Workshop in the Western Quarter of Palmyra, w: *StP* 8/1985, s. 43–67

**Kropp, Lohmann 2011**

A. J. M. Kropp, D. Lohmann, “Master, look at the size of these stones! Look at the size of these buildings!” (Mk.13.1) Analogies in Construction Techniques Between the Temples at Heliopolis (Baalbek) and Jerusalem, w: *Levant*, vol. 43, no. 1/2011, s. 38–50

**Krunić 1964**

J. Krunic, Hatra, l’Architecture des Temples au Centre de la Ville: Questions relatives à leur reconstitution, w: *Revue Archéologiques* 1/1964, s. 7–32

**de Laborde 1837**

L. de Laborde, *Voyage en Orient: Voyage de la Syrie*, Paris 1837

**Lamprecht 1994**

H. Lamprecht, *Opus Caementicium. Bautechnik der Römer*, Düsseldorf 1994

**Leick 1988**

G. Leick, *Dictionary of Ancient Near Eastern Architecture*, London 1988

**Lohmann 2008**

D. Lohmann, Giant Strides Towards Monumentality. The Architecture of the Jupiter Sanctuary in Baalbek/Heliopolis, w: *Bulletino di Archaeologia on line, vol. Speciale. International Congress of Classical Archaeology. Meetings Between Cultures in Ancient Mediterranean*, Rome 2008, s. 22–29

**Lugli 1957**

G. Lugli, *La tecnica edilizia romana*, vol. I-II, Roma 1957

**Lyttelton 1974**

M. Lyttelton, *Baroque Architecture in Classical Antiquity*, London 1974

**Łukaszewicz 1979**

A. Łukaszewicz, Some remarks on P.LOND. III.755 and the problem of building materials in the fourth century A.D., w: *Archeologia* 30/1979, s. 115–118

**Machowski 2007**

W. Machowski, *Petra. An Archaeological Guide*, Charlston 2015

**Majcherek 2005**

G. Majcherek, More churches from Palmyra -an inkling of the late antique city, w: Bieliński, Stępniewski (ed.), *Aux pays d'Allat, Mélanges offerts à Michał Gawlikowski*, Warszawa 2005, s. 141–150

**Majcherek 2009**

G. Majcherek, Polish Archaeological Mission to Palmyra. Season 2008 and 2009, w: *PAM 21, Research 2009* vol. 21/2009, s. 459–479

**Majcherek 2013**

G. Majcherek, Excavating the Basilicas, w: *StP* 12/2013, s. 251–268

**Majcherek in print**

G. Majcherek, Late Roman military Horreum in Palmyra, w: M. Gawlikowski, D. Wielgosz-Rondolino, M. Żuchowska (eds.), *Life in Palmyra, Life for Palmyra. Proceedings of the Conference in Memory of Khaled al-As'ad, 1934–2015*, Warszawa, in print

**Makowiecka 1966**

E. Makowiecka, Bramy rzymskie w Syrii, w: *StP* 1/1966, s. 20–45

**Makowski 1985**

K. Makowski, La sculpture funéraire palmyréenne et sa fonction dans l'architecture sépulcrale, w: *StP* 8/1985, s. 69–117

**Malacrino 2010**

C. Malacrino, *Constructing the Ancient World. Architectural Techniques of Greeks and Romans*, Los Angeles 2010

**Maqdisi in print**

M. al Maqdisi, Travaux de R. du Mesnil du Buisson à Palmyre (1965 et 1967) d'après les archives inédites conservées au Musée du Louvre (DAP), w: M. Gawlikowski, D. Wielgosz- Rondolino, M. Żuchowska (eds.), *Life in Palmyra, Life for Palmyra. Proceedings of the conference in Memory of Khaled al-As'ad 1933–2015*, Warszawa, in print

**Marta 1986**

R. Marta, *Tecnica Construttiva Romana. Roman Building techniques*, Roma 1986

**Matthews 1984**

J. Matthews, The Tax Law of Palmyra: Evidence for economic history in a city of the Roman East, w: *Journal of Roman Studies* 74/1984, s. 157–180

**McKenzie 1990**

J. McKenzie, *The Architecture of Petra*, 1990

**MacDonald 1982**

W. L. MacDonald, *The Architecture of the Roman Empire, An Introductory Study*, Binghampton 1982

**Meyer 2013**

J. C. Meyer, City and hinterland. Villages and estates north of Palmyra. New perspectives, w: *StP* 12/2013, s. 269–286

**Meyer 2017**

J. C. Meyer, *Palmyrena. Palmyra and the Surrounding Territory from the Roman Period to the Early Islamic Period*, Oxford 2017

**Miller 1948**

A. Miller, *Stone and Marble Carving*, London 1948

**Misztal 2017**

B. Misztal, *Kopuły drewniane*, Warszawa 2017

**Misztal 2018**

B. Misztal, *Wooden Domes. History and Modern Times*, Cham 2018

**Murray 1917/1970**

S. B. Murray, *Hellenistic Architecture in Syria*, Princeton 1917 / Amsterdam 1970

**du Mesnil du Buisson 1969**

R. du Mesnil du Buisson, Odkrycie najstarszej Palmyry, *StP* 3/1969, s. 101–103

**Meyza 1985**

H. Meyza. Remarks on the Western Aqueduct of Palmyra. w: *StP* 8/1985, s. 27–33

**Michałowski 1960**

K. Michałowski, *Palmyre 1. Fouilles polonaises 1959*, Warszawa 1960

**Michałowski 1962**

K. Michałowski, *Palmyre 2. Fouilles polonaises 1960*, Warszawa 1962

**Michałowski 1963**

K. Michałowski, *Palmyre 3. Fouilles polonaises 1961*, Warszawa 1963

**Michałowski 1964**

K. Michałowski, *Palmyre 4. Fouilles polonaises 1962*, Warszawa 1964

**Michałowski 1966**

K. Michałowski, *Palmyre 5. Fouilles polonaises 1963 et 1964*, Warszawa 1966

**Minke 2013**

G. Minke, *Podręcznik budowania z gliny*, tł. Z. Bieliński, *Hanbuch Lehmbau*, Siemianowice Śląskie 2013

**Mislin 1997**

M. Mislin, *Geschichte der Baukonstruktion un Bautechnik, Band 1: Antike bis Renaissance*, Berlin 1997

**De Montfaucon 1719/1757**

B. de Montfaucon, *L'Antiquité expliquée et représentée en figures*, vol. I–V, Paris 1719, Supplement, Paris 1757, nt. Palmyry, vol. III, pl. 104, s. 181–182

**Müller-Wiener 1988**

W. Müller-Wiener, *Griechisches Bauwesen in der Antike*, München 1988

**Muller 1989**

W. Muller, *Architekten in der Welt der Antike*, Leipzig 1989

**Nassar 2014**

M. Nassar, Hadriana's Arch's from Roman Period, Jordan: A Comparative Study, w: *Mediterranean Archaeology and Archaeometry*, vol. 14/2014, s. 247–259

**Netzer 1990**

E. Netzer, Architecture in Palestina Prior to and During the Days of Herod the Great, w: *Akten des XIII Internationalen Kongresses für Klassische Archäologie Berlin 1988*, Mainz 1990, s. 37–50

**Netzer 2006**

E. Netzer, *The Architecture of the Herod, the Great Builder*, Tübingen 2006

**Noack 1910**

F. Noack, *Die Baukunst der Altertums*, Berlin 1910

**Olson 2010**

R. G. Olson, *Technology and Science in Ancient Civilisations*, Santa Barbara 2010

**Orlandos 1966–1968**

A. Orlandos, *Les matériaux de construction et la technique architecturale des anciens Grecs*, vol. 1–2, Paris 1966, 1968

**Ostrasz 1966**

A. Ostrasz, Etudes sur la restauration du Grand Tétrapyle, w: *StP* 1/1966, s. 46–58

**Ostrasz 1969**

Note sur le plan de la partie médiane de la rue principale de Palmyre, w: *AAAS* 19/1969, s. 109–120

**Ostrasz 1989**

A. Ostrasz, The Hippodrome of Gerasa. A report on Excavations and Research 1982–1987, w: *Syria* 68/1989, s. 51–77

**Parlasca 1985**

K. Parlasca, Figurliche Stuckdekorationen aus Palmyra, Alte Funde, w: *DaM* 2/1985, s. 201–206

**Parlasca 1989**

K. Parlasca, Beobachtungen zur palmyrenischen Grabarchitektur, *DaM* 4/1989, s. 181–190

**Parnicki-Pudełko 1977**

S. Parnicki-Pudełko, Budownictwo, w: K. Majewski (ed.), *Kultura materialna starożytnej Grecji*, Wrocław 1977, vol. 2, s. 345–475

**Patrício, Stevens 2003**

T. Patrício, T. Stevens, The Roman theatre of Jebel in Syria: Analysis of the construction form, w: S. Huerta et al. (eds.), *Proceedings of the First International Congress on Construction History, Madrid 20–24, January 2003*, Madrid 2003, s. 1602–1612

**Pausanias 1968–1989**

Pausanias, *Periegesistes tes Hellados*, tł. J. Niemirska-Pliszycka, Pauzaniasz, Wędrówki po Helladzie; t. 1: *Na olimpijskiej bieżni i w boju. Ks. IV, V, VI*, Wrocław 1968; t. 2: *W świątyni i mieście. Ks. I, II, III, VII*, Wrocław 1973; t. 3: *U stóp boga Apollona, ks. VIII, IX, X*, Wrocław 1989

**Pena 1984**

J. T. Pena, P. Giss. 69: evidence for the supplying of stone transport operations in Roman Egypt and the production of fifty-foot monolithic column shafts, w: *Journal of Roman Archeology* 2/1989, s. 126–132

**Perez 1988**

N. Perez, *Focus East. Early Photography in the Near East (1839–1885)*, Jerusalem 1988

**Photios 1996**

Photios, *Bibliotheka*, tł. O. Jurewicz, Focjusz, *Biblioteka*, t. 4: *Kodeksy 238–248*, Warszawa 1996

**Pietrzykowski 1997**

M. Pietrzykowski, *Adyta świątyń palmyreńskich. Studium funkcji i formy*, Warszawa 1997

**Pismo Święte 2014**

*Pismo Święte Starego i Nowego Testamentu (Pallottinum)*, Poznań 2014

**Plinius 2004**

Plinius, *Naturalis Historia*, tł. I., T. Zawadzcy, Pliniusz, *Historia naturalna (wybór)*, t. 2, Wrocław 2004

**Plinius 2017**

Plinius, *Naturalis Historia*, tł. I. Mikołajczyk, N. Rataj, *Historia naturalna. Tom I: Kosmologia i Geografia, ks. II–VI*, Toruń 2017

**Precht 1991**

G. Precht, Maschinelle Vorfertigung von Säulentrommeln, w: Hoffmann et al. 1991, s. 178–183

**Procopius 2006**

Procopius, *De aedificis*, tł. P. Ł. Grotowski, *Prokopiusz z Cezarei, O budowlach*, Warszawa 2006

**Rababeh 2005**

S. Rababeh, *How Petra was built: An analysis of the construction techniques of the Nabatean freestanding buildings and rock-cut monuments in Petra, Jordan*, Oxford 2005

**Rababeh, El Mashaleh, Al Malabeh 2011**

S. Rababeh, M. El Mashaleh, A. El Malabeh, Factors Determining the Choice of the Construction Techniques in Petra, Jordan, w: *International Journal of Architectural Heritage*, vol. 5/2011, s. 60–83

**Rababeh, Khafajah, Al Qablan, 2014**

S. Rababeh, S. Abu Khafajah, H. Al Qablan, Structural utilization of wooden beams as anti-seismic and stabilizing techniques in the stone masonry in Qasr al-Bint, Petra, Jordan, w: *Construction and Building Materials*, 54/2015

**RLA 1971**

E. Heinrich, Gewölbe, w: E. Weidner et al. (eds.), *Reallexicon der Assyriologie und vorderasiatischen Archäologie*, Berlin – New York 1957–1971, vol. 323–338

**Reuther 1938**

O. Reuther, Parthian Architecture. A History, w: A.U. Pope (ed.), *A Survey of Persian Art I*, London, New York 1938, s. 411–444

**Robertson 1979**

D. S. Robertson, *Greek and Roman Architecture*, Cambridge 1979

**Rzewuski 1821**

W. Rzewuski, Podróż do Palmiry, czyli Tedmory ... z zastanowieniem się nad wiatrem Samieli zwany w pustyni tej panującym, w: *Dziennik Wileński*, t. 2, 1821, s. 416–430

**Rzewuski 2017**

W. Rzewuski, *O koniach wschodnich wywodzących się z ras orientalnych*, 5 tomów, Warszawa 2017

**Ruprechtsberger (ed.) 1987**

E. M. Ruprechtsberger (ed.), *Palmyra. Geschichte, Kunst und Kultur der Syrischen Oasenstadt*, Linz 1987

**Sachau 1883**

E. Sachau, *Reisen in Syrien und Mesopotamien*, Leipzig 1883

**Sadurska 1966**

A. Sadurska, Problematyka i historia badań Palmyry, *StP* 1/1966, s. 7–19

**Sadurska 1977**

A. Sadurska, *Palmyre 7. Le tombeau de la famille de Alaine*, Warszawa 1977

**Safar, Mustafa 1974**

F. Safar, M. A. Mustafa, *Hatra – The City of the Sun God*, Baghdad 1974, 1976

**Saito 1995**

K. Saito, Excavation at the Southeast Necropolis in Palmyra from 1990–1995, w: *ARAM* 7/1995, s. 19–28

**Saliby 1996**

N. Saliby, Maisons Palmyréniens à l'est du Temple de Nabû, w: *AAAS* 42/1996, s. 289–290

**Saliou 1996**

C. Saliou. Du portique à la rue à portiques. Les rues à colonnades de Palmyre dans le cadre de l'urbanisme romain impérial: originalité et conformisme, w: *AAAS* 42/1996, s. 319–330

**Sartre 1991**

M. Sartre, *Wschód rzymski. Prowincje i społeczeństwa prowincjonalne we wschodniej części basenu Morza Śródziemnego w okresie od Augusta do Sewerów (31 r. p.n.e. – 235 r. n.e.)*, Wrocław 1991

**Sartre 2007**

M. Sartre, Domestic Architecture in the Roman Near East, w: Gallor-Waliszewski (eds.) 2007, s. 25–36

**Sartre 2016**

A. et M. Sartre, *Palmyre. Verites et legends*, Paris 2016

**Savino 1999**

E. Savino, Citta di frontiera nell'Impero romano: Forme della romanizzazione da Augusto ai Severi, w: *Pragmateiai* 1, Bari 1999, 69–75

**Schlumberger 1933**

D. Schlumberger, Les forms anciennes du chapiteau corinthien en Syrie, en Palestine et en Arabie, w: *Syria* 14/1933, s. 291–302

**Schlumberger 1970**

D. Schlumberger, *L'Orient helleénisé. L'Art Grec et ses héritiers dans l'Asie non méditerranéenne*, Paris 1970

**Schmidt-Collinet 1986**

A. Schmidt-Collinet, Flachdach und Giebel. Zur Bekrönung des Tempelgrabes nr. 86 von Palmyra, w: G. Bucher (ed.), *Orient und Okzident im Spiegel der Kunst. Festchrift Heinrich Gerhard Fraz zum 70 geburtstag*, Graz 1986, s. 329–331

**Schmidt-Collinet 1990**

A. Schmidt-Collinet, Considerations sur les carrières de Palmyre en Syrie, w: M. Waelkens (ed.), *Pierre éternelle, du Nil au Rhin, Carrières et prefabrication*, Bruxelles 1990, s. 87–92

**Schmidt-Collinet 1992**

A. Schmidt-Collinet, *Das Templegrab nr 36 in Palmyra. Studien zur Palmyrenischen Grabarchitektur und ihrer Ausstattung*, Mainz 1992

**Schmidt-Collinet 1995**

A. Schmidt-Collinet, The Quarries from Palmyra, w: *ARAM*, vol. 7/1995, s. 53–58

**Schmidt-Collinet 1996**

A. Schmidt-Collinet, *Antike Denkmäler in Syrien. Die Stichvorlagen von Louis Francois Cassas (1756–1827) im Walraf-Richartz-Museum in Köln*, Köln 1996

**Schmidt-Collinet 1997**

A. Schmidt-Collinet, Tomb Architecture at Palmyra and its Decoration, w: S. Alcock (ed.), *The Early Roman Empire in the East*, Oxford 1997, s. 157–177

**Schmidt-Collinet 2005**

A. Schmidt-Collinet, Stuck und Wandmalerei aus dem Area der “Hellenistischen Stadt” von Palmyra, w: Bieleński, Stępniewski (eds.) 2005, s. 225–241

**Schmidt-Collinet, al-As'ad 2013**

A. Schmidt-Collinet, W. al-As'ad (eds.), *Palmyras Reichtum durch Weltweiten Handel. Archäologische Untersuchungen im Bereich der Hellenistischen Stadt, Band I, Architektur und ihre Ausstattung*, Wien 2013

**Schmidt-Collinet 2016**

A. Schmidt-Collinet, The Reconstruction and Distribution of Pattern Books in the Roman Empire. Some Archaeological evidence from Palmyra, w: G. Adomato, *Inforno al Papiro di Artemidoro III, I disegni*, Milano 2016, s. 129–146

**Scholl, Taha 1997**

T. Scholl, A. Taha, A Sounding in the Courtyard of the Saray in Palmyra 1986, w: *StP* 10/1997, s. 63–69

**Schnadelbach 2010**

K. Schnadelbach, *Topographia Palmyrena, I Topography*, Damascus 2010

**Schwandner 1991**

E. L. Schwandner, Der Schnitt im Stein. Beobachtungen zum Gebrauch der Steinsäge in der Antike, w: Hoffmann et al. (eds.) 1991, s. 216–223

**Scranton 1941**

R. L. Scranton, *Greek Walls*, Cambridge Mass. 1941

**Sear 2006**

F. Sear, *Roman Theatres. An Architectural study*, Oxford 2006

**Segal 1998**

A. Segal, The Temple at Musmiyeh in Relation to the Religious Architecture in Roman Palestine, w: *Assaph. Studies in art history*, 3, 1998, s. 109–130

**Seigne 1985**

J. Seigne, La sanctuaire de Zeus à Jerash: éléments de chronologie, w: *Syria* 62/1985, s. 287–295

**Seigne, Yon 2005**

J. Seigne, J. B. Yon, Documents nouveaux de la grande colonnade de Palmyre, w: Bieliński, Stępniewski (eds.), Warszawa 2005, s. 243–255

**Seigne in print**

J. Seigne, Palmyre: de l'eau dans la steppe syrienne, w: M. Gawlikowski, D. Wielgosz-Rondolino, M. Żuchowska (eds.), *Life in Palmyra. Life for Palmyra. Proceedings of the Conference in Memory of Khaled al-As'ad, 1934–2015*, Warszawa, in print

**Seyrig 1940**

H. Seyrig, Antiquités Syriennes, Ornamenta Palmyrena antiquora. Remarques sur la civilisation de Palmyre, w: *Syria* 21/1940, s. 277–337

**Seyrig, Amy, Will 1968, 1975**

H. Seyrig, R. Amy, E. Will, *Le temple de Bêl à Palmyre*, vol. 1 Album, Paris 1968, vol. 2 Texte et Planches, Paris 1975

**Smith 1978**

E. B. Smith, *The Dome. A study in the history of ideas*, Princeton 1978

**Smith II 2013**

A. M. Smith II, *Roman Palmyra: Identity, Community and State Formation*, Oxford 2013

**Starcky, Gawlikowski 1985**

J. Starcky, M. Gawlikowski, *Palmyre*, Paris 1985

**Stern 1977**

H. Stern, *Les mosaïques des Maisons d'Achille et de Cassiopee à Palmyre*, Paris 1977

**Strzygowski 1901**

J. Strzygowski, *Orient oder Rom*, Leipzig 1901

**Tabaczek 2002**

M. Tabaczek, *Zwischen Stoa und Suq. Die saulenstrassen im Vorderen Orient in romischer Zeit unter besonderer Berücksichtigung von Palmyra* (diss. Universität Köln 2002)

**Tabaczek 2004**

M. Tabaczek, Die Säulenstrassen des Vorderen Orients. Die Entstehung eines Monumenttypus in Spannungsfeld zweier Kulturen, w: A. Schmidt-Collinet (ed.), *Lokale Identitäten in Rundgebieten des Römischen Reiches. Akten des Internationalen Symposiums in Wiener Neustadt*, 2003, Wien 2004, s. 209–221

**Tanabe 1986**

K. Tanabe, *Sculptures of Palmyra*, Tokyo 1986

**Teofrast 1956**

Theophrastos, *Peri Ton Lithon*; tl. E. Galey, J. Richards, *Theophrastus on Stone*, Columbus Ohio 1956

**Theodosiev 2000**

N. Theodosiev, Monumental Tombs and Hero Cults in Thrace during the 5<sup>th</sup>-3<sup>rd</sup> centuries BC, w: V., Pirenne-Delforge, E. Suarez de la Torre (eds.), *Heros et heroines dans les mythes et les cultes grecs, Actes du Colloque organisé à l'Université de Valladolid 1999* – Kernos, Supplement no 10, Liege 2000, s. 435–447

**Terlikowski, Narloch 2013**

W. Terlikowski, P. L. Narloch, Specificity of research and reconstruction of ancient wall constructions in Syria, the area of Palmyra, w: M. Boriani et al. (eds.), *Built Heritage 2013: Monitoring, Conservation, Management, online proceedings of the Conference*, Milano 2013, s. 176–183

**Texidor 1983**

J. Texidor, “Le Tarif de Palmyre” I un commentaire de la version palmyréenne, w: *Aula Orientalis I*, 1983, s. 235–252

**Texidor 2005**

J. Texidor, Palmyra in the Third Century, w: E. Cussini (ed.), *A Journey to Palmyra: Collected Essays to Remember Delbert R Hillers*, Leiden, Boston 2005, s. 181–226

**Thompson 1990**

Mons Claudianus and Mons Porphyrites: The Roman Quarries in the Red Sea Mountains of Egypt, w: *Akten des XIII Internationalen Kongresses für Klassische Archäologie Berlin 1988*, Mainz 1990, s. 448–449

**Tomlison 1987**

R. A. Tomlison, The Architectural Context of the Macedonian Vaulted Tombs, w: *Annual of British School of Athens*, vol. 82/Nov. 1987, s. 305–312

**Torber 2013**

B. Torber, Stuck und Wandmalerei, w: Schmidt-Collinet, al-As'dad (eds.), *Palmyras Reichtum durch Weltweiten Handel archäologische Untersuchungen im Bereich der Hellenistischen Stadt*, Band I: Architektur und ihre Ausstattung, Wien 2013

**Ulatowski 1970**

K. Ulatowski, *Architektura starożytnej Grecji*, Warszawa, Poznań 1970

**Van Beek 1987**

G. W. Van Beek, Arches and Vaults in the Ancient East, w: *Scientific American*, 257/1987, s. 78–85

**Vann 1976**

R. L. Vann, *A study of Roman construction in Asia Minor: the Lingering Role of Hellenistic Tradition of Ashlar Masonry*, diss. Cornel University script 1976, Ann Arbor Michigan Microfilms International (1985)

**Vitruvius 1956**

Vitruvius, *De architectura libri decem*, tl. K. Kumaniecki, Witruwiusz, *O Architekturze ksiąg dziesięć*, Warszawa 1956

**Volney 1795**

C. F. Volney, *The ruins: or A survey of the revolutions of empires*, London 1795

**Waelkens 1987**

M. Waelkens, Adoption of Roman Building Techniques in the Architecture of Asia Minor, w: S. Macready, F. H. Thompson (eds.), *Roman Architecture in the Greek World*, London 1987, s. 94–105

**Waelkens (ed.) 1990**

M. Waelkens (ed.), *Pierre éternelle du Nil au Rhin, Carrières et Fabrication*, Bruxelles 1990

**Waelkens 1990**

M. Waelkens, Technique de Carrière, prefaconnage et ateliers dans les civilisations classiques (monde grec et romain), w: M. Waelkens (ed.) 1990, s. 53–72

**Ward Perkins 1958**

J. B. Ward Perkins, Notes on Structural and Building Methods of Early Byzantine Architecture, w: Talbot Rice D., (ed.) *The Great Palace of the Byzantine Emperors II*, Edinburgh 1958, s. 52–104

**Ward Perkins 1981**

J. B. Ward Perkins, *Roman Imperial Architecture*, 1981

**Wąsowicz 1975**

A. Wąsowicz, Obróbka drewna, w: K. Majewski (ed.), *Kultura materialna starożytnej Grecji, Zarys*, Wrocław 1975, s. 273–333

**Wegner 1957**

M. Wegner, *Ornamente kaiserzeitlicher Bauten Roms. Soffiten*, Köln, 1957

**Wesenberg 1991**

B. Wesenberg, Zur Entstehung des griechischen Keilsteingewölbes, w: Hoffmann et al. (eds.) 1991, 252–258

**White 1984**

K. D. White, *Greek and Roman Technology*, London 1984

**Wiegand (ed.) 1932**

T. Wiegand (ed.), *Palmyra. Ergebnisse der Expeditionen von 1902 und 1917*, Berlin 1932

**Wielgosz 2005**

D. Wielgosz, La présence de marbres précieux à Palmyre, w: Bieliński, Stępniewski (eds.) 2005, s. 303–323

**Wielgosz 2013**

D. Wielgosz, Coepimus et lapide pingere: Marble Decoration from the so Called- Baths of Diocletian in Palmyra, w: *StP* 12/2013, s. 319–332

**Wilcox 1981**

R. P. Wilcox, *Timber and Iron Reinforcement in Early Buildings*, London 1981

**Wilcke, Thunig 1987**

H. Wilcke, W. Thunig, *Kamieniarstwo*, Warszawa 1987

**Will 1946**

E. Will, La tour funéraire de Palmyre, w: *Syria* 26/1946/9, s. 87–114

**Will 1966**

E. Will, Du trilithon de Baalbek et d'autres appareils colossaux, w: M. L. Bernhard et al. (eds.), *Mélanges offerts à Kazimierz Michałowski*, Warszawa 1966, s. 725–729

**Will 1983**

E. Will, Le développement urbain de Palmyre: témoignages épigraphiques anciens et nouveaux, w: *Syria* 60/1983, s. 69–81

**Will 1985**

E. Will, La maquette de l'adyton du Temple de Niha (Beqa), w: J. M. Bommelaer (ed.), *Le dessin d'architecture dans les sociétés antiques, Actes du Colloque de Strasbourg*, Leiden 1985, s. 272–281

**Will 1997**

E. Will, Les salles de banquet de Palmyre et d'autres lieux, w: *TOPOI* 7/1997, 873–887

**Wingate 1985**

M. Wingate, *Small-scale lime burning. A Practical introduction*, London 1985

**Winkels 2013**

A. Winkels, Mörtelanalysen von Stuck und Wandmalerei, w: Schmidt-Collinet, al-As'Ad (eds.), *Palmyras Reichtum durch Weltweiten Handel. Archäologische Untersuchungen in Bereich der Hellenistischen Stadt, Band I, Architektur und ihre Ausstattung*, Wien 2013

**Wipszycka 1979**

W. Wipszycka, Metrologia, w: E. Wipszycka (ed.), *Vademecum historyka starożytnej Grecji i Rzymu*, Warszawa 1979, s. 333–344

**Wright 1985**

G. R. H. Wright, *Ancient building in South Syria and Palestine*, t. 1, Leyden 1985

**Wright 1992**

G. R. H. Wright, *Ancient Building in Cyprus*, Leyden 1992

**Wright 1999**

G. R. H. Wright, *Ancient Building Technology, vol. 1: Historical Background (Technology and Change in History)*, Leyden 1999

**Wright 2005**

G. R. H. Wright, *Ancient Building Technology, vol. 2: Materials*, Leyden 2005

**Wright 2009**

G. R. H. Wright, *Ancient Building Technology, vol. 3: Construction (part 1 text)*, Leiden, Boston 2009

**Zanini 1995**

E. Zanini, Il restauro giustinianeo della mura di Palmira, w: A. Iacobini, E. Zanini (eds.), *Arte profane e arte sacra a Bisanzio, (Milon. Studi e Ricette d'arte Bizantina 3)*, Roma 1995, s. 65–103

**Zayadine, Larche, Dentzer-Feydy 2003**

F. Zayadine, F. Larché, J. Dentzer-Feydy, *Le Qasr al-Bint de Pétra. L'Architecture, le décor, la chronologie et les dieux*, Paris 2003

**Ziomecki 1975**

Juliusz Ziomecki, *Obróbka gliny*, w: K. Majewski (ed.), *Kultura materialna starożytnej Grecji. Zarys*, Wrocław 1975, s. 335–395

**Zosimos 2012**

Zosimos, *Historia nova*, tł. H. Cichocka, *Nowa historia*, Warszawa 2012

**Żuchowska 2000**

M. Żuchowska, Quelques remarques sur la Grande Colonnade à Palmyre, w: *Bulletin d'Etudes Orientales* 52/2000, s. 187–193

**Żuchowska 2003**

M. Żuchowska, Palmyra. Test Trench in the Street of the Great Colonnade, w: *PAM* 16/2003, s. 291–294

**Żuchowska 2006**

M. Żuchowska, Palmyra. Excavations 2002–2005. Insula E by the Great Colonnade, w: *PAM* 18 (Reports 2005)/2005, s. 439–450

**Żuchowska 2008**

M. Żuchowska, Wadi Al Qubur and its interrelations with the development of urban space of the City of Palmyra in the Hellenistic and Roman Periods, w: H. Kühne et al. (eds.) *Proceedings of the 4th International Congress of the Archaeology of the Near East, vol. 1, The Reconstruction of Environment: Natural Resources and Human Interrelations through time. Art History: Visual communication*, Wiesbaden 2008, s. 229–234

**Żuchowska 2010**

M. Żuchowska, The Western Gate at Palmyra, w: *StP* 11/2010, s. 107–114

**Żuchowska 2011**

M. Żuchowska, Space Organization and House Planning at the Hellenistic and Roman Palmyra, w: *Świato-wid* 9 (50) A/2011, s. 141–153

**Żuchowska, Juchniewicz 2013**

M. Żuchowska, K. Juchniewicz, Remarks on water supply in Palmyra. Results of a survey in 2010, w: *PAM* 22 (season 2010) /2013, s. 341–350

# Building Construction Techniques in Ancient Palmyra

## – summary

The book presents the development of Palmyra's architecture in relation to the changes which took place in construction techniques and their application. These changes resulted from an individual approach to ancient Greek construction technique introduced at the beginning of the 1<sup>st</sup> century AD, employed in the construction of the great Temple of Bel. An analysis of the development enables the understanding of the factors that influenced the breakthroughs and advances in construction skills and knowledge.

A natural spring flowing in the middle of the Syrian Desert gave rise to a small but important oasis settlement which developed into a famous ancient city of Tadmor/Palmyra. For the desert-dwelling groups of Nomads, Palmyra was a religious centre dedicated to god Bel. The knowledge of the desert and the control over the trade routes between the East and the Roman Empire brought enormous wealth to the inhabitants of Palmyra. In the 1<sup>st</sup> century AD, an ambitious project was undertaken to build a new, huge temple to the main god Bel. The project owed its inspiration to similar structures already created in the nearby religious centres. For the local community, the construction of the temple was a challenge on a scale previously unheard of. This brought about the employment of master-masons of the Greek construction tradition. The construction works necessitated the introduction of new technical ideas and solutions as well as enforced the opening of a new quarry. The stone extracted from the quarry not only turned out to be of very good quality, but was also suitable for cutting large, monolithic blocks. As the construction of the temple progressed, the local masters had an opportunity to learn and gradually adapt new technical solutions through small-scale projects, such as tower tombs primarily. Further development of the city was marked by the creation of many monumental buildings, in which changes permitting more effective construction methods could be observed. The development was stimulated by the optimal use of the properties of the local stone as well as the knowledge of the possible applications of the crane. However, the advances in construction techniques did not include the skill of building voussoir arches. Instead, solutions based on the corbelled arch were used until the beginning of the 3<sup>rd</sup> century. The conducted analysis of the structures built in Palmyra showed that despite the lack of trees in the desert environment, timber was brought to Palmyra in large quantities, which facilitated the construction of ceilings, but did not drive the need to use stone vaults. The situation changed only in the 3<sup>rd</sup> century, when closer contact with Roman military engineers was established. This resulted in the acquisition of knowledge of the structure and construction of stone arches. The unprecedented development of the local community of Palmyra, which had the status of municipium of exceptional independence in the Roman period, was brought to a dramatic end when Queen Zenobia, a local ruler, made an attempt to become the monarch of the eastern territories of the Roman Empire. The lost war terminated further development of the city in 272 AD. From then onwards, no larger buildings, apart from the legionary camp and defensive walls, were constructed in the city. The prominent and prestigious buildings of the camp were made of demolition material. Such an approach was practised in the construction of early Christian churches and the conversion of old villas into houses. The fall of the city continued till the 10<sup>th</sup> century AD, when a powerful earthquake destroyed the place so seriously that the small community had to move to the area of the Bel Temple, the temenos, in order to create a modest settlement there. The final large-scale projects conducted in ancient Palmyra were the construction of a mosque and

the strengthening of the Propylaea of the Bel Temple, converted into a defence gate of the settlement. This was the state Palmyra was found in when the ancient city was discovered by the Europeans at the end of the 17<sup>th</sup> century. Over the centuries that followed, the ruins of Palmyra were the focus of intense research aiming at better understanding of the history of the city, its art and architecture. The research conducted on the methods of construction of Palmyrene buildings presented in this monograph book has given deep insights into the factors affecting both the construction processes and techniques and, consequently, shown their character as well as the technical approach and skills of the local master-masons in a new light. These issues are outlined in the subsequent chapters of the book.

### **Why Palmyra? Why its buildings and the construction techniques used in them?**

This chapter presents the key issues of the author's research interests concerning the individual and unique characteristics of Palmyrene buildings. The research indicated that both the desert location and the new developmental impetus initiated by the construction of the Bel Temple, which enabled the introduction of novel technical as well as structural possibilities, prepared the ground for innovative construction solutions. The amazing development of the city required solutions capable of facilitating the construction works carried out in the adverse desert oasis conditions. The conducted research indicated that the processes proceeded differently from those occurring in the neighbouring areas of the Middle East. An analysis of the structures and construction techniques employed in Palmyra revealed a sequence of logical developments resulting from both the technical advances and the experience gained in previous construction works. This building tradition developing independently in Palmyra was a unique case in the ancient world. The new Roman construction solutions such as the arch, or the mortar vault used in other cities of the Middle East, were skilfully adapted to the local conditions in Palmyra. Thus, the specific situation encountered in Palmyra, where there were no classic voussoir arch structures till the early-3<sup>rd</sup> century, is an interesting message showing the engineering consciousness of the ancient designers, constructors and master-masons. The flux of the Roman *know-how* did not turn out to be an obvious phenomena, even for the communities cooperating closely with the Empire. The solutions observed in the neighbouring areas were not known in Palmyra either.

### **The history of the ancient city**

The impressive wealth of the city as well as its spectacular fall after Queen Zenobia's seizure of power are well known from the records of ancient historians. These events, however, are but a part of another story, the essence of which was building the magnificent city in a fairly short time. Learning the history of the city, its unique character, conditions and prerequisites will allow the reader to understand the basics of its development. The city enjoyed great independence within the Roman Empire. Such a situation was conducive to generating huge incomes through trade by the merchants travelling across the desert. The proud citizens felt inspired to create a new image of their city so that it could equal the other centres of the ancient world. Indeed, the city went through considerable changes, thus gaining its monumental character. However, the new temples built in a classical form revealed distinct features of the earlier structures, and the Allat Temple is a clear case of preservation of an earlier building. The magnificent development of the city was achieved by a relatively small community. The situation in Palmyra changed fundamentally under the Roman occupation. A legionary camp was established, the city was divided and its better, more modern and monumental part was surrounded and protected by defensive walls. The new buildings constructed in the city within a year utilised extensively the materials and embellishments from the old dismantled structures. Such practices lasted virtually into the Middle Ages, when in the 12<sup>th</sup> century the last monumental building was constructed in the ruined city.

### **The modern discovery of Palmyra**

The interest taken in antiquities which sprang in the 17<sup>th</sup>-century Europe and continued throughout the 18<sup>th</sup> century prompted courageous travellers to cross the desert and to discover Palmyra. The result of the expeditions was the preparation of demonstrative descriptions and drawings as well as performing surveys and taking measurements of the ruined city and its most significant buildings. The famous description of Palmyra by Rev. William Halifax along with the images of the city ruins by Hofsted van Essen, published

in 1695, is well worth mentioning. The folio published by Wood and Dawkins as well as the drawings made by Cassas were the milestones on the road to getting to know the site. The 19<sup>th</sup> century spawned a series of expeditions to Palmyra which produced descriptions of the city and the first photographs of its ruined buildings. In this period, however, Palmyrene inscriptions and finds of grave sculptures sparked a more passionate interest. The 20<sup>th</sup> century was a period of archaeological research and significant broadening of the knowledge of urban planning and architecture of the city. Excavation works were carried out by the German, the French, the Polish, the Swiss, the Japanese and the Italian teams. But the research focused on the embellishments and architecture of Palmyrene historic structures rather than on the technique of their production. A general assumption was made that the advances in civil engineering in Palmyra were the result of both the continuation of the excellent construction methods already employed in the building of the Bel Temple and the influence of Roman architecture.

### The major historic buildings

Palmyra is a place with a diverse architecture. There are monumental temples, with the most significant one, the Bell Temple and its huge temenos, as well as smaller sanctuaries, such as the temples of Nebo, Baalshamin and Allat. Surprisingly, the Temple of Allat, rebuilt in the mid-2<sup>nd</sup> century AD, revealed an earlier structure, dating back to the mid-1<sup>st</sup> century BC. The preserved structure of the temple bears a similarity to another early shrine, the Temple of Rab'asire. Consequently, Palmyra displays interesting comparative records of both the early temples and those constructed later, by using classic techniques. The characteristic Palmyrene family tower tombs permit extensive comparisons of the subsequent changes in their structure as well as the identification and classification of the applied construction and finishing techniques. The influence of new ideas in architecture caused a departure from the structure of a high tower. Instead, in the mid-2<sup>nd</sup> century, one- or two-storey lavishly decorated sepulchral buildings, called temple tombs, started to appear. From the mid-1<sup>st</sup> century AD onwards, a significant number of family underground tombs started to be built. Some of them were parts of tower tombs, whereas others were separate structures made in compacted soil. Although the structure of these underground sepulchres may seem to be related to the structure of a family tomb from the Hellenistic times, there are certain criteria, including technical solutions, that exclude direct correspondence of the underground tombs and the earlier model of family tomb, the only one discovered so far. The city's monumental architecture is represented by structures such as the Agora, the Annex by the Agora, the porticos of both the Great Colonnade and the Transverse Colonnade, the Theatre, the Monumental Arch and the Propylaea, i.e., the monumental entrance to the temple grounds (temenos), the construction of which probably involved the alteration (raising) of the whole western wall of the temenos. Another stage of the development of Palmyra's monumental architecture was the construction of the Great Gallery after the dismantling of the double portico of the temenos. The structures constructed in the 3<sup>rd</sup> century AD to provide embellishment for the Great Colonnade include the Great Tetrapylon, the nymphaea and the arches at section B of the Great Colonnade that marked the crossing with side streets. The remains of the houses identified and researched in Palmyra are reflective of the architecture of the 2<sup>nd</sup> and the 3<sup>rd</sup> century AD. An early house located in the southern part, which is the only one researched so far, may date back to the 1<sup>st</sup> century BC. This puts it in the category of late-Hellenistic structures. The western aqueduct is another significant facility of historical value apart from the diverse city's buildings. Other special engineering structures include a dam built in a valley west of the city, collecting and storing the waters of the Wadi River as well as the defensive walls, fairly simple in structure, utilising the natural irregular ground layout around the city. A structure with outstanding defensive features is a fragment of a preserved thick wall, the construction of which was triggered by the real threat of attack by Aurelian's army. The Roman occupation of Palmyra resulted in the construction of a legionary camp, where the Principia, the headquarters' building as well as the defensive walls surrounding the northern part of the city were the dominant structures. The Romans marked their presence in Palmyra by constructing public baths, adapting the presumed residence of the rebel Queen Zenobia to suit their needs. It can be assumed that the villa was used by the legionary commanders until the building of the Principia was constructed in the Diocletian's Camp, and was changed into public baths afterwards. In the 4<sup>th</sup> century AD, during the Christian period, some of the ancient temples were converted into churches. Also, new churches were constructed. The biggest church of Palmyra, referred to as the *Cathedral*, was built during the reign of Emperor Justinian, in

the 6<sup>th</sup> century. In this period, the defensive walls of the city were strengthened, which was achieved by the addition of fortified towers permitting flanking fire of the army attacking the walls. The Islamic period in Palmyra saw the filling and shutting of the northern section of the Great Colonnade with a line of stalls that formed a part of the Arab souk. Near the souk, the first mosque was built, based on the former Caesarion. A powerful earthquake that destroyed the city in the 11<sup>th</sup> century made the surviving inhabitants move their households and fill the temenos of the Bel Temple. They utilised the defensive character of the place, which could be noticed in the conversion of the former Propylaea into a defence gate. The Temple of Bel was adapted into a mosque.

### Bibliographical references

In order to facilitate the use of the extensive bibliography of the historic buildings of Palmyra, a selection was made of the items that present and comment in full on the construction techniques and structural solutions applied both in individual buildings and in groups of buildings. The bibliographical references describing particular objects as well as groups of monuments discuss the issues in question in the most complete way. Specific references also include photographs and drawings showing the structural and construction solutions which are the focus of the author's research interests and which are not always presented in the cited basic source material.

### The research on the antique building techniques

The research conducted on the construction techniques and structural solutions is an interesting multi-angled issue. The chapter debates and comments on both the works of many authors dealing with specific structure types, tools and construction techniques as well as the papers synthesising the author's focal issues of interest in specific areas and periods. Special emphasis has been placed on the issue of construction of monumental buildings, where the use of large monolithic elements necessitated the application of cranes. The arch structure, which was employed as a corbel-based solution by the Palmyrenes, is an issue of great interest to the author. This structure was modified due to the application of local stone. The ceilings built in Palmyra were made of timber. Attention is drawn to the possible use of the so-called light vaulting structure, constructed by means of a timber rib frame, plastered or stuccoed afterwards. Although such structures have not survived to our times, their application in the Middle East was mentioned by ancient authors.

### Palmyra – building materials, opportunities, prerequisites and conditions

The general principle of construction is using the materials obtained locally. Hard limestone permitting the quarrying of monolithic blocks and slabs was an important material utilised in Palmyra from the 1<sup>st</sup> century AD onwards. This significantly affected the development of construction techniques and structural solutions. The desert location of Palmyra also imposed certain limitations. The lack of water and timber was an important factor. Interestingly, despite these limitations, both timber and the so-called wet techniques based on lime mortar and gypsum decorative stucco plaster are applied in Palmyra. An analysis of this situation was conducted and a conclusion was put forward that a mass import of timber and fuelwood was a fundamental prerequisite for broadening the scope of construction opportunities. Despite the limited access to timber, construction ceramics, such as roof tiles and water supply pipes, were manufactured in Palmyra. The author's attention was drawn to the commercial activity of merchants, who may have imported timber as return loads. The import of fuelwood also permitted local lime burning. Yet, in order to use burnt lime, access to water must have been provided. For that purpose, a dam storing winter rainwaters flowing down the Wadi River was built west of the city. The water resource was probably used in agriculture as well as in the production of mortar. Indirectly, the research on the Palmyrene construction techniques contributed to the broadening of the knowledge of the functioning of the ancient city.

### Building techniques in Palmyra before the construction of the Temple of Bel

The oldest recognised structures in Palmyra were constructed with the application of simple construction techniques as well as roughly cut stones bound with clay and gypsum mortar. The outer faces of the walls were trowelled with mortar or clad with blocks of soft limestone. Easy to carve, soft limestone was used

for architectural embellishment. Among the structures of historical value constructed in that period there are numerous tower tombs made of roughly cut stone. The multi-storey Atenatan Tower has an impressive height of 20 metres. Arches and corbelled vaults were useful structures employed in the construction of such buildings. However, the lack of a method of appropriate stone refinement, their cutting and fitting did not permit the construction of spans larger than 1 – 1.5 m in the burial chambers. The only researched underground tomb from that period is quite an unusual structure dating back to the 2<sup>nd</sup> century BC. The walls of the tomb passage are clad with mud brick. The structure features a mud-brick arch with a span of 0.9 m. An analysis of the early tower tombs from the 1<sup>st</sup> century BC showed that they were constructed without the application of specialised cranes or lifting equipment. This was evidenced by the size of the stone used in that period as well as by the method of erecting high tower tombs by moving along and upwards their inner perimeter.

### The construction of the Temple of Bel and its outcome

The construction of the Temple of Bel became a determinant of the changes that affected both the structure and the building techniques. The Greek master-masons employed in Palmyra applied classic solutions of ashlar walls (*opus quadratum*). The construction of such a large temple required high-quality, durable stone. The opening of a new quarry ensured supplies of hard white limestone with specific properties enabling the extraction of large blocks and slabs with a span of up to 5 metres. In order to erect structures made up of large blocks, the application of tools and devices such as sheaves, blocks and tackles as well as advanced cranes was necessary. Special attention should also be paid to another fact. The Temple of Bel is not merely a large structure made of ashlar by means of classic techniques. It is a building with an unusual plan and surprisingly bold structural solutions. The stone ceiling over the peristasis of the temple is but one of the unusual solutions. Here an interesting issue is explored by the author – to what extent the size of the temple was the result of the approved design project and how much it was determined by the actual structural capacity of the local stone. The conducted analyses of the temple indicated that a fundamental alteration may have been introduced in the original design project. This brought about a change of the axis of the building and necessitated a relocation of the temple entrance to the longer elevation, which produced its interesting asymmetrical position. A structural analysis of this transformation indicated that it required performing additional difficult construction works on the entrance gate and the portal, both of which had a large span. Experience gained during the construction of the northern adyton of the temple, where a wide opening was shut with a large stone block, was used. The change introduced in the plan enabled the addition of another adyton on the southern side. Here, however, a major construction error may have appeared. It may have resulted from imprecise conversion of measurements of particular elements from one system into another. No more great temples were built in Palmyra afterwards, but the knowledge acquired while building the Temple of Bel was applied successfully during the construction of other structures in the city.

### Observing the construction of the Great Temple

The 1<sup>st</sup>-century Palmyra saw the construction of many public buildings. The Temple of Nebo, the first Agora and monumental family tombs were built along with the Bel Temple. An analysis of these objects showed that although hard, white limestone was used there, the scale of its application in this period was relatively modest. Besides the public buildings, it was used in a few construction projects only. One of them was a tall honorific column erected in 64 AD in front of the temple of Allat. Material limitations can be noticed clearly in the tower tombs constructed in that period by the wealthy citizens of Palmyra. In many cases, the application of hard limestone in decorative lintels over the tomb entrances was symbolic of the changes to come. The structure of these objects changed dynamically over a period of 60 years only. The improvements introduced there were a consequence of the technical advances which could be noticed during the construction of the Temple of Bel. The application of the crane had a significant impact. It enabled the use of ceiling blocks as well as larger stone blocks in the construction of walls. In order to move such blocks efficiently during the construction process, it was necessary to produce elements with relatively levelled wall courses. However, all of the changes were hindered by the limited access to a new quarry. Initially, the application of larger blocks of hard limestone as ceiling blocks only was observed. This permitted the widening of the narrow burial corbelled chambers. In the mid-1<sup>st</sup> century, this change was

accompanied by a noticeable improvement in the methods of construction and refinement of the internal walls of the burial chambers. The application of cut blocks of stone permitted a more efficient utilisation of the cubic volume of the structure and an increase in the number of loculi (burial compartments). The quality of the methods employed in construction and refinement works improved vastly, and in ca. 80 AD verticality of ashlar walls was finally obtained. The ceilings made up of large slabs of white limestone had spans of up to 3 metres. With the completion of the Temple of Bel, an increase in the number of buildings made of white limestone was observed.

#### **The extensive development of the city (period of AD 80 to AD 200)**

After the completion of the Temple of Bel in ca. 80 AD, the city entered a period of construction of large public buildings, in which the structural scheme of portico was repeated. The porticos constructed at that time became higher and had a larger span. The Agora, the Agora Annex, the porticos of the temenos of the Bel Temple as well as the columned porticos constructed in the Great Colonnade from the 2<sup>nd</sup> century AD are examples of buildings incorporating the scheme. A structural issue that needs to be addressed here is whether the roofs were flat, slightly raised or pitched so that they could be tiled. The issue of the flat roof structure, widely adopted in Palmyra, is analysed in terms of span layout and rainwater drainage from clay roofing. Since there are finds of roof tiles that were produced locally, this may indicate the application of roofs with higher pitch at that time. The number of tiled roofs appears to be higher than it has been assumed so far. In the early-2<sup>nd</sup> century AD, there was an increasing number of examples of buildings constructed by means of the *classis* technique of ashlar wall. The examples of such buildings include the Temple of Baalshamin and the Temple of Allat. Large slabs of hard limestone were used in the construction of ceilings in tower tombs. Interestingly, around the mid-2<sup>nd</sup> century, large stone slabs were also applied in the construction of walls. In the same period, a new structural solution appeared, in which the shafts of smaller columns were no longer built of individual drums, but of long stone sections cut off the bedrock along the stone strata. This enabled the production of monolithic column shafts up to 5 and 6 metres in length. Another interesting research objective is the Theatre. It features 6-metre-high monolithic columns and a *scaenae frons* made up of large, elongated stone blocks laid in Isodomic bond, which was a completely new solution in Palmyra at that time, enabling the introduction of major changes in the construction of house walls in future. The vaults over the side entrances to the Theatre stage are another interesting solution employed here. Although the building was erected at the end of the 2<sup>nd</sup> century AD, it displays a solution drawing upon the corbelled arch structure. The research conducted on the arch structures identified in Palmyra showed that although arches were used by the Palmyrene master-masons, they were not constructed of voussoirs, but of cut blocks projecting towards the archway's centre, just like in the corbelled arch structure. A variety of technical solutions were employed here in order to increase the strength of such structures. These were elongated arch stones providing counterweight as well as rebated joints, the function of which was to stabilise the blocks against possible slipping. An engineering analysis of these solutions classified them as corbelled-arch structures. Similar solutions can be found in the underground tombs, but the vaulting there was intended as a decorative form imitating either the vault or the dome shape, made in thin slabs of soft limestone bound with mortar at the back.

#### **The dynamic development of Palmyra (period of AD 200 to AD 272)**

The 3<sup>rd</sup> century was a period of a dynamic development of the city, when scores of monumental buildings were constructed. The Monumental Arch, with its unique structure, is one of them. It is an example of corbelled arch, in which regular voussoirs were not used. Both the appropriate application of hard limestone and the technical solutions known in Palmyra enabled the construction of an arch with a span of almost 7 metres. Its structure indicates that voussoir arches were not constructed in Palmyra till the early-3<sup>rd</sup> century. This can be explained by the fact that the local master-masons did not have sufficient knowledge of the principles of construction of such arches. On the other hand, it is interesting to note that arch structures were not particularly frequently applied in the treeless city of Palmyra. It was caused by the mass import of timber, which permitted a quick and easy construction of roofs as well as the so-called light vaults, which might have been a substitute for structures otherwise made of stone or brick. The light vault is a timber ribbed structure which could be finished with lath and plaster covering. The situation changed in the middle

of the 3<sup>rd</sup> century, when voussoir arch structures appeared, along with the extension of the Great Colonnade. It can be assumed that this fundamental change was a result of direct contacts with legionary engineers, who made such a technological transfer while residing in Palmyra during the period of cross-border fights between the Roman Empire and Sassanid Persia. Other monumental buildings constructed in that period include the western gallery of the temenos of the Temple of Bel, already expanded by the Propylaea of the temple, the portico in front of the nymphaeum in section C of the Great Colonnade, the Tetrapylon and the monumental portico in front of the residence later converted into public baths. The height of the new structures exceeded the height of the earlier buildings. Monolithic granite columns were used in the construction of the Tetrapylon and the portico of the public baths. These structures prove that in that period the techniques enabling the use of much larger elements than those applied earlier were well mastered. The introduction of a new method of erecting walls by using long stone slabs was a confirmation of the changes. This specific solution was called *opus palmyrenum*. A technical analysis of the structure showed that the application of larger elements resulted in faster construction. However, bringing to perfection the method of lifting and assembling large slabs was considered a necessary prerequisite.

### The Roman, Christian and Islamic Palmyra

The conquest of Palmyra in 272 AD ended the period of the development of the city. After 273 AD, a Roman legionary camp was built along with defensive walls around the northern part of the city. Separating one part and changing it into a walled zone soon made the southern part of the city depopulate. While building the camp, the Romans used the construction material and the decorative elements acquired from the dismantled buildings constructed in the 3<sup>rd</sup> century. The long slabs from the walls constructed in *opus palmyrenum* were used to erect the front walls of the Principia. Many columns were moved to the camp in order to build street porticos and arches in the Forum Gate as well as the apse of the Principia cella. The lack of new construction projects in the city and the long-standing construction of the defensive walls brought about the disappearance of the highly-developed construction technique. Practically no major projects were carried out in Palmyra apart from the city walls. This situation also resulted in the withering of local sculptor's and stonemason's workshops. It was only in the 4<sup>th</sup> century that Christian churches started to be constructed. Some of them adopted the earlier buildings, while others were made of spolia, utilising the material from demolition. In this way, the largest church in Palmyra was constructed in the times of Emperor Justinian in the 6<sup>th</sup> century. An analysis of the building indicated that during its construction large-span timber arch structures were implemented in order to support the roof over the church. The church was a project carried out by foreign builders who were brought to Palmyra. After the Arab conquest, one row of the Great Colonnade was filled and shut with stalls made of the demolition material, and the first mosque was constructed next to them, using the same material. The great earthquake that destroyed the city caused the surviving inhabitants to move to the less ruined temenos of the Bel Temple. The simple buildings constructed there contrasted with the 12<sup>th</sup>-century defence gate within which the ancient Propylaea of the temenos of the Temple of Bel were incorporated. The gate was made of the blocks of the temenos wall, which enabled perfect fitting of the smooth sides after being turned by 90 degrees. Another interesting solution implemented there was a structure protecting the entrance by means of three different load bearing systems. This monumental structure was a project constructed by external builders who were brought to work in Palmyra. The 11<sup>th</sup>-century mosque constructed within the Temple of Bel is a building which is relatively poorly recognised, and the structure of which was later altered significantly.

### Quo vadis Palmyra?

The modern discovery of Palmyra has revealed its magnificent complex of ruins set in a unique landscape of a green desert oasis, located at the foot of a mountain slope. The well-preserved temples featured classic structural and construction solutions and top-notch sculptures as well as bas-reliefs. However, a more thorough analysis of the buildings proved that the city did not develop solely owing to the application of the excellent classic construction methods. The Roman construction techniques exerted a relatively minor impact. In general, the advances in construction techniques followed the stages of acquisition of the new design and construction methods. However, there were surprising changes and limitations that spurred the development of new solutions. Constructing arches and vaults in the

form of corbelled structures was a surprising tendency at that time. The Monumental Arch, built at the beginning of the 3<sup>rd</sup> century, is a vivid example of such a structure. In the years that followed, a spectacular development of the city, stimulated, among others, by the application of new structural solutions and construction techniques, was observed. Sadly, the amazing development, which resulted in the creation of a new political centre in the east of the Roman Empire, was dramatically interrupted in 272 AD. The centuries that followed brought numerous acts of destruction to the great historic buildings. Fortunately, an analysis of the structures and construction techniques employed in the city permitted the identification of development sequences, which revealed their individual and unique character in contrast to other external culture centres in the Middle East. The development ideas and strong conservative tendencies turned out to go side by side, which was stimulated by the ease of access to timber, purchased in large quantities by the opulent Palmyrenes. The perfectly preserved ancient monuments facilitated the understanding of the development processes implemented by the local master-masons. This unique heritage of ancient Palmyra provided an opportunity to interpret the intellectual approach of the ancient builders, who adopted the arch structure they had seen and managed to adapt it into the construction solutions they knew. The ambition of the local master-masons combined with the full utilisation of the potential of the local material resulted in the construction of numerous structures which did not appear in other centres of the ancient world. In 2015, Palmyra's most valuable historic buildings that constituted the material records of all the intellectual achievements, were barbarously destroyed. Their reconstruction is now a challenge for us, aimed at restoring not only the former shape and beauty of the buildings but also their construction methods. Carved and inscribed in stone, the processes of intellectual development of ancient builders, their understanding and interpretation of structures as well as means of utilisation of the local material make up the unique value of the monuments. Palmyra is a an exceptional site, where the intellectual message of the ancient approach to the use of building materials as well as the adoption of structural solutions, preserved in a material form, has survived to our times. This has opened up an opportunity to examine the historic buildings and draw in-depth conclusions concerning the engineering mind of the ancient builders.