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Theses of a Ph.D. dissertation

CRAFT HISTORICAL, SHAPE AND CONSTRUCTIONAL COMPONENT STUDY EXAMINATION OF TIMBERRED WOODEN ROOFS IN ACCORDANCE WITH THE EXAMPLES OF "BURCSELLA" ROOF STRUCTURES OF GYŐR

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1. Scientific problems, appointed tasks, methods of examinations

The so-called "burcsella", baroque and baroque-like roofs of Győr are *the structure and operation versions* of the groups limited in time and space of the *medieval and modern roof structures of Middle-Europe*. The concepts of *Győr and timberred wood roofs* can be connected via *burcsella roof structures*. Both the determination of their place in time and in the historic structure development and the analysis of their local historic and town picture forming function, and building motivation are meaningful and worthy tasks. The purpose of the chief-research-worker is to introduce, discover, analyse the possibilities and processes of saving, preservation, competent utilization of the historic roof structures and to add to the scientific grounding of the activities.

The analyses of shapes and structural operations of real examples lead to a *more exact, degraded definition, explanation of the structure-categories*: medieval, medieval-like, gothic, gothic-like, modern, baroque, baroque-like, eclectic, eclectic-like historic roofs, roof structures, roofing, roof frames introduced earlier by others. The range of *mixed and interim structures* often mentioned in the trade but not yet defined by scientific accuracy need to explain exactly, and their important groups also need to define. The examination of interim structure groups can provide important lessons also about *some structure development processes*. Within the sets of roof-types managed uniformly until today (medieval roofs, modern roofings, etc.) it is possible to find and discover *additional structure versions, and development trends which can be clearly separated*.

Considering the historic roofs as uniform room covering supporting and constructional structures several relations certify that the *rational roof and structure forming* based on traditions have developed, changed and evolved in their relationship influencing mutually each other. It is concluded from the functional examinations of *supporting structures* that their *roles have been changed or modified* in time.
The *elements having been almost equal* at the beginning have been *classified or counted in a hierarchical order* gradually formed. The empirical constructing and the genial anticipations have been displaced by the more and more awared structure forming and the will of realization of the more and more followable load cycles, respectively. Examinations should also be extended to the element relations and the *traditional timber joints*. *Systematization and analyses* of real solutions and their comparison with the experiments of literature can be the tools of the *theoretical structure reconstruction.*

Roofs and high-pitched roofs are also built today. In comparison with the old ones our technical tools can be used for much more free space and mass forming. However, do we consider the possibilities of *saving, preserving, renewal, introduction and utilization* of historic buildings and *historic roofs*? If we did not do so, we would kill the spirit of the place we are living in, and we could be at home nowhere and never in this world. The task is duty. The *authentic realization* can be hoped from a scientific grounding.

The historic structures behave similarly to living organisms: their sustentation, reclamation, resuscitation of immunities can be done by *complex therapeutical interference* developed in accordance with curious *diagnoses and pathological examinations* and analyses. The exact diagnosis requires narrowly detailed information of the body or structure, and the exact determination of their components. The proposed *building and structure diagnostical professional system applied for the historic roof structures made of wood* is suitable for completing the task soon and covering to several structures or structure groups. A main part of the task is the *uniform terminology*, which can be *applied also for historic roof structures*.

Besides the rough and fact-like approach, and the feeble and peecable body: the examination of the structure suffering from declining process, another task of authenticity is to understand and transmit the *messages of the past and preterite composers, constructers, builders, and protectors*. The real features of history can be discovered after the exact recognition of history and local history. Also in case of Győr, the today town picture of the centre have been developed for a long historic period. Fortunately, one of the most characteristic and determinant part of this town picture is still the *historic roof scenery*.
Most of the historic roofs of Győr are baroque or baroque-like. Burcsella roofs have been erected above buildings of variable plans, ages and styles. The structure was well fitted to walls with different and variable clearances.

The stress of the roofs of the crowded centre cut by wide and straigh streets jammed in the walls of the fortress according to the aspects of protection but also preserving the medieval winding alleys produces the *really specific feature of Győr*. The former Main Square is in the gravity centre of the triangle of the introduced buildings of Győr. Saving, renewal and utilization of the burcsella, baroque-like roof structures can be an example and *provide other and other lessons* also as the analyses, systematization and classification of several other cases from the studied literature. Considering the lessons some *proposals* have been produced, which can help the *appreciative and authentic preservation of more roofs* in the future.

During my research several *real structure examples* of the timberred historic roofs referred and studied by *own field information gathering*, or *found and referred in literature* have been analysed. Six burcsella roof sections of three buildings in Győr typical for the studied stock have been examined using field data collection. The number of selected and introduced structures is *twenty-one* using the figures of the referred sources – essentially for the illustration of the individual structure-types. In the *figures selected and made by me the examples are systematically processed* and there are *nineteen* medievial or medievial-like roofs, *twelve* baroque or baroque-like roofs, and *nine* mixed-type or interim roofs. The results of examinations can be utilized, which is certified by the lessons of case-studies of *twelve* roof rehabilitation of the final chapter.

Methods of examinations: *Comparative analysis of shape-study* in the examination of structure operation and development. Building and supporting structural *function discoveries and complexity-examinations* with regard to structural elements, element-groups and element-relationships. Analysis of the *development and physiognomy of the town picture* on the historical phases of the roof scenery of the centre of Győr. *Development of a uniform structure-terminological proposal* for the academic documentation and expansion of the value-keeping tools of historical roofs. *Analyses of case-studies* on the possibilities of usabilities.

II. Theses

Thesis 1 *(basic structure groups of historic roofs made of wood)*

The *historic roof structures** have been developed during an evolutional development independent on the former, ancient results to satisfy the variable architectural demands. All the three basic evolutional levels can be originated from simple principles and individual structure forming intuitions. The *gothic roofs*** consist of closed triangular, stiffened joined rafters (principle rafters and common rafters) and longitudinal plane frames being always vertical. The stable, load bearing, stiff-in-space, permanently true-to-shape roof structure was realized by building the plane units together. In *baroque roofs**** the roof frame formed by space rigidly building the tilted longitudinal frames and the principle rafters operating as a cross together. In *eclectic roofs***** the posts loading the joists bear coupled rafters (later spars) and suspend joists forming truss constructions.

*	European medieval and modern historic roofs
**	gothic, gothic-like, medieval, and medieval-like
***	baroque, baroque-like and burcsella
****	eclectic and eclectic-like

Thesis 1.a *(definition of joined rafters)*

The elements (forming a closed triangle with the joist) of *joined rafters - called by me* – of gothic roofs are present in all rafters, so all rafters are balanced theirselves but the principle rafter is stiffer. The joined rafters are primary load bearing elements. (Their tasks: crust bearing, stiffening and balancing of rafters)

Thesis 1.b *(definition of coupled rafters)*

The baroque collar-beam roofs are *called as coupled rafters* because joists are only connected by the legs of the principle rafters (supported by pentagonal pole plates). Balancing of common rafters is the common task of tilted plane frames and header and tail joists. The coupled rafters are secondary load bearing elements. (Their tasks: crust bearing, stiffening of rafters)

Thesis 1.c *(definition of spars)*

The truss constructions of eclectic roofs formed from posts bear also coupled rafters being on purlins, which are also secondary load bearing elements in this case. The separated *spars – called by me –* are directly supported by purlins. Spars are tertiary load bearing elements. (Their tasks: crust bearing)

Thesis 2 *(space rigid, truss bearing supporting frame; definition of roof frame)*

The spatial support constructional frame of baroque roofs being self-stiff are called as *baroque roof frames, baroque-like or burcsella roof frames*.
(I have not met with any individual names, yet)

Thesis 3 *(principle post with braced angle frame)*

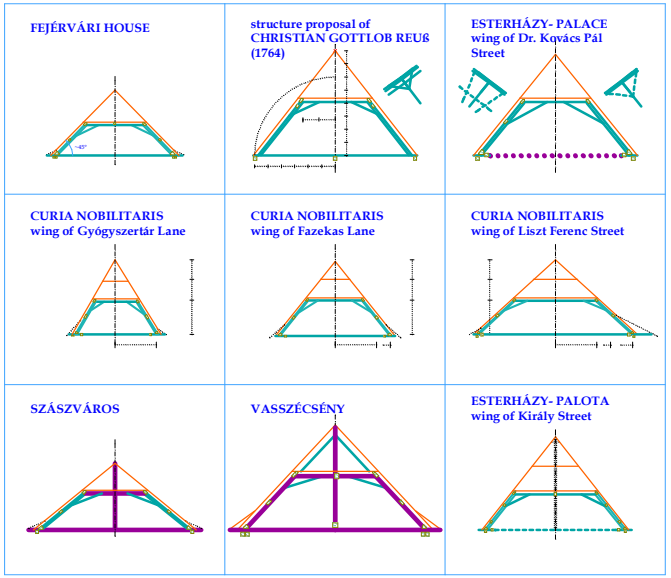
The baroque principle post is a *braced angle frame* considering its development. The trapezoid closed rod-chain standing on the longer side consisting of hinge rods have been developed by rotating the plane frames into the level of the roof (to provide place for the arches). Its new element is the simply-supported, eccentrically loaded, horizontal *hammer brace*. This rod-chain is only stable for vertical and symmetrical loads, so the upper angles should be stiffened by *knees*.

Thesis 4 *(cross stiffening effects of longitudinal frames)*

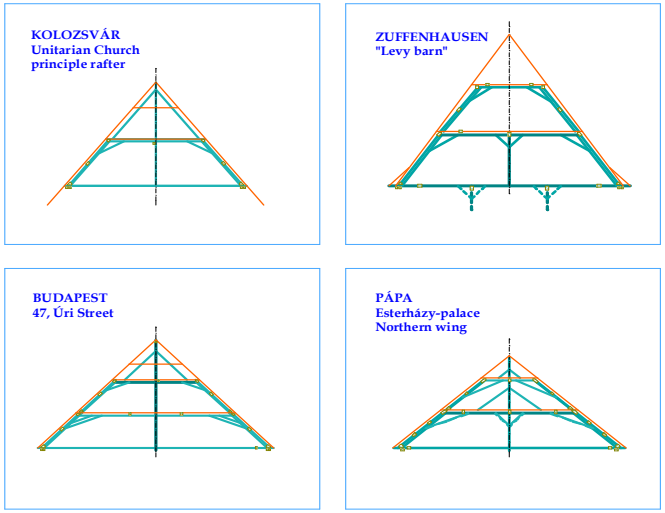
The baroque longitudinal frames also stiffen in cross direction because they are not parallel but battered. Trusses of common rafters are discharged by principle rafters. The secondary rafters without tie-beams are balanced in cooperation with header and tail joists.

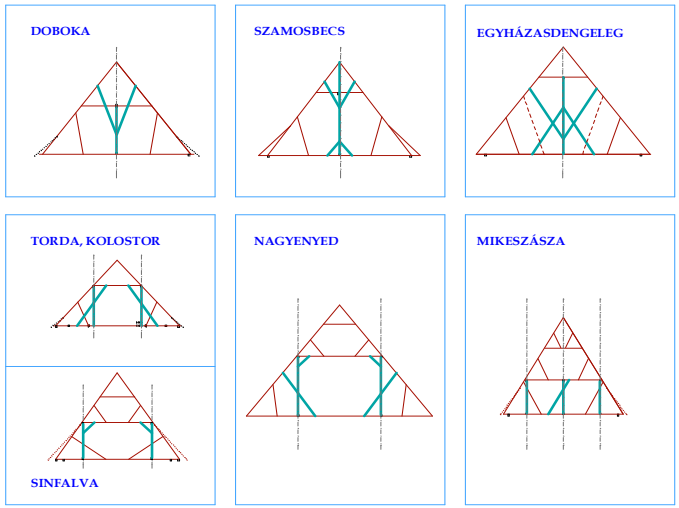
Thesis 5 *(structure identification and coding of historic roofs made of wood)*

The *structure identifying code-system* (theasurus) made for the structure disgnosing technical professional databases of structure maintaining planning systems *has been extended to the range of historic roof structures.*

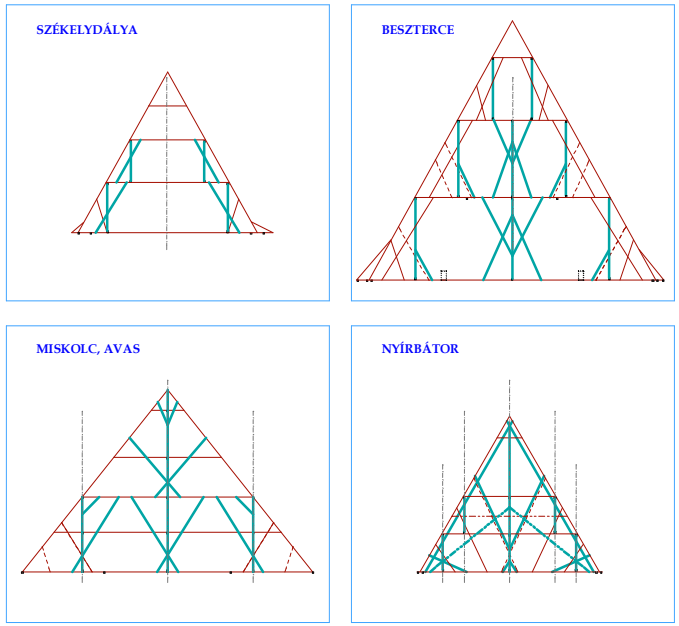


One and two floored baroque roof frames





„Magyarországi”, egy hosszrácsos, „erdélyi”, több hosszrácsos, és „egyesített” típusú középkori tetőszerkezetek



Thesis 5.a *(time sectioning of structure-classification)*

The medieval roofs with the name of *gothic roofs* in the system – similarly to the baroque and eclectic structures – *do not mean their architectural style*, at the best they refer to the style of the covered building. In case of medieval-, gothic-, baroque- and eclectic-like roofs “*like*” means a roof structure of uncertain age or originating outside a specific time-limit. Our *proposals for the time-limits*: medieval-like or baroque: after 1642, baroque-like or eclectic: from the 19th century, eclectic-like or modern: from the 30s of the 20th century.

Thesis 5.b *(separation of medieval roff structure groups)*

Two basic cases of the medieval roof structures that can be separated clearly: *structures with one longitudinal frame “of Hungary” and with several londitudinal frames “of Transylvania”*. The *“joined” type* have reached the limits of the room covering possibilities of gothic constructional method by summing the solutions of the two basic cases.

Thesis 5.c *(definition of roof structures with mixed systems)*

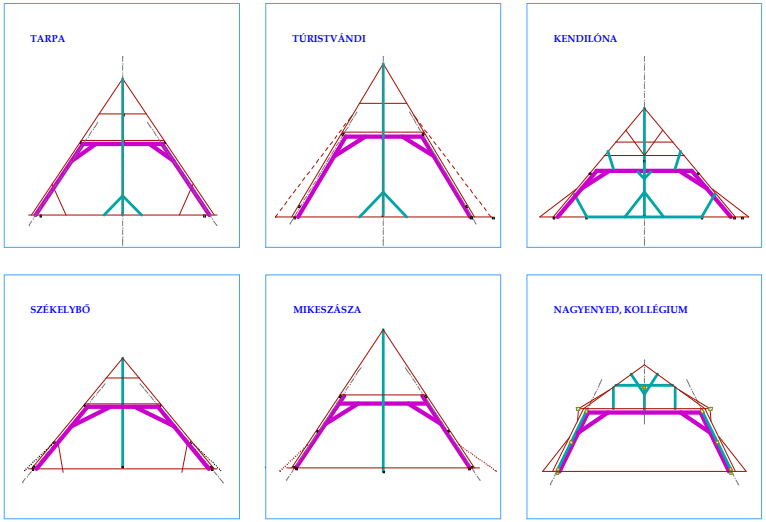
The forming frame of the *historic roof structures with mixed systems* have medieval and baroque features and joined rafters.

Thesis 5.d *(definition of roof structures with interim systems, their two groups)*

One group of the roof structures with interim systems bear rafters with medieval elements on frames of baroque or baroque-like features. The structures of the *other group* have both classical baroque frames and eclectic supporting elements.

Thesis 6 *(development of the baroque frame)*

The shape analysis of the structures with mixed systems have discovered the *development process of the baroque frame*.



The features of shapes of roof structures with mixed and interim systems
Development of the baroque frame

Thesis 7 *(structure-terminology of historic roofs made of wood)*

With the use of the uniformly explained, overall and detailed structure-terminology regarding also the structure operation of historic roofs and the multi-charactered features of their elements developed in accordance with my research-experiments a building and structure diagnosing professional system of timberred wooden roofs effectively operable can be established.

Thesis 7.a *(spars, rafters, rafts, trusses and rafter roofs)*

There are *three types of rafters* in timberred roof structures (according to 1.a, 1.b, and 1.c) considering their tasks: *joined rafters, coupled rafters and crusted rafters.*
In the principle and secondary rafters of a roof structure *and its rafters* there are always joined rafters. In the *principle and secondary posts* of a roof structure there are only coupled or crusted rafters.
Both *joined or (multiple) coupled rafts (rafters*) can be in medieval structures.
Both *coupled or multiple coupled rafts (rafters*) can be in baroque roof structures.
The collar-beam roof includes *joined, and coupled rafts (rafters*).
The collar-beam roof without joists can be called as a *coupled rafter roof.*
The closed coupled roof also includes *joined rafts (rafters*).

Thesis 7.b *(definition of purlin)*

The *name of the bent element* supported in several points, stiffed usually by bolsters or knee, *directly bearing the crusted rafters*: medium purlin (sometimes arris or ridge beam, rafters bearing beam).

Thesis 7.c *(definition of crown-plate or binding beam)*

The *name of the bent element* supported in several points, stiffed usually by bolsters or knee, *directly bearing collar-beam of joined rafters*: crown-plate or binding beam.

Thesis 7.d *(definition of header)*

The *name* of the longitudinal, load bearing, *eccentrically compressed or pulled structural elements* of the stiffening plane frames: header, medium purlin, and pole plate (not real purlins, the rafters are not supported directly but as frame elements).

Note: The rafters bearing beams and arris beams are often only locating *constructional elements*, also as *crust bearing purlins* laid on the rafters with base roles.

Thesis 7.e *(transversal horizontal elements of wooden roofs)*

The transversal horizontal element of timberred roof structures can be called as joist if its basic load is the eccentral tension. The transversal horizontal elements basically eccentrally compressed: *collar-beam, top beam and hammer brace.*

Notes: The top beam and collar-beam connect rafters, the hammer brace supports back props, posts and suspension woods. (The top beam is the top level of a rafter or raft –not being on *the crown plate or purlin beam* – that includes collar-beams.) The *double collar* being in the roof frame is a locating *constructional element.* (It is loaded by tension rarely and pressing force is not accepted.)

Thesis 7.f *(inner tilted elements of timberred wooden roofs)*

The inner tilted element of timberred roof structures are *brace* when basically eccentrically compressed, and it is *(angle-)binding* when basically (eccentrically) pulled. The simply-supported *angle wood* can be both (eccentrically) pulled and (eccentrically) compressed. Its special casea are the (usually 45 °) *angle-(wood) or binder* connecting the vertical and horizontal elements, and the *knee* connecting the horizontal and tilted elements. The name of the multi-span, (eccentrically) pulled/compressed inner, tilted element: *tilted stiffening beam*.

Thesis 7.g *(post, trussing post, truss)*

The vertical element of the timberred roof structures are called *posts* if its basic load is the (eccentrical) compression. It is called *trussing post* when it is the part of a *longitudinal vertical frame* and it can also suspend indirectly (sometimes it can be compressed). It is called *truss* when its basic load is the (eccentrical) tension, és it can *directly suspend*.

Note: The post of the baroque londitudinal frame is a *diagonal brace* in the principle post.

Thesis 7.h *(gothic and baroque-like wood binding)*

The traditional wood binding[1] the *element-relations* of historic roofs have been developed parallelly with the development of basic operation modells and in the service of them. The conscious and combinative use of shear and cocked binding following the *gothic-like* halved joints have appeared in the *baroque-like* connections. The use of suspension and dimensions exceeding the natural limits have led to the *binding forms of eclectic structures* with the use of metal and hardwood fills, and connecting elements.

Thesis 8. *(historic roof as building structure)*

The development of empirical supporting structures of historic roofs has also been motivated by *constructional aspects and possibilities* in significant extent:

The usually simply-supported historic roofs clamp, and use the exterior bearing walls in the horizontal directed load bearing but also cover and preserve them.
The gradient of approximately 60 ° of gothic roofs and the characteristic features of their stiffened rafters have been developed mainly due to the use of the applicable covering method (wooden shingle).
The accuracy, durability of the roof geometry of the flatter pantiled roofs with the gradient of approximately 45 ° was provided by the equality and adjustability of the coupled baroque rafters with collar-beams and repeated by roof posts.
The sprocket piece connected by dove-tail joints makes the gothic rafters more rigid, and the wall loading more centralized. The consoled baroque joist- and tail joist-ends support the sprocket piece and load the baroque crown cornice.
The baroque and baroque-like roof structure have become simply broken flat, and constructable with the use of crusts closing better (slate, and metal plate).

[1] It was useful to process the *timber joints of historic wooden roofs*. It was proved that the examinations of wooden binding can be theoretical and sometimes practical tools of structure reconstructions. For example in case of the former removed individual stiffeners of knees of longitudinal frames on the Northern side of the wing of dr. Kovács Pál Street of Esterházy-palace of Győr. (Figures 2.51 – B7., B21.) In this theoretical reconstruction a literature structure proposal has also been helpful. [55]

Thesis 9. *(supporting structural element tasks and element groups)*

The elements of historic roof structures complete *several supporting structural tasks*. The basic condition of the development of a uniform structure operation theory is the exact definition and systematization of the tasks. The elements and their tasks can be classified according to three basic operational models: gothic, baroque and eclectic structures. The gothic model can be disaggregated to equivalent plane frames, its elements can be classified in it, although there are some common elements. The baroque model can be disaggregated to primary spatial roof frames and secondary planar rafters. The primary planar units of the baroque frame are the frameworks of principal posts and the battered tilted plane frames. The classification of elements can also be planar, although there are also common elements. Functional element groups (posts, trusses and truss constructions) can be separated in the principle posts of eclectic roofs. The purlin becomes independent.

Thesis 10. *(historic roof structures and roof scenery are factors forming the town picture)*

The examination of historic structures can give accurate results in real historical surroundings. I have introduced the historic forming of the town picture of the centre of Győr in a short local historical chapter highlighting the *important physiognomy-forming stress of the roof scenery*. The *specific development of Győr* – layering the historic country-forms on each others – *has motivated* not only the architectural styles to live together but the *development of very specific roof forms*. The baroque and baroque-like roofs of Győr can be well fitted to the process of evolutional structure development of historic roofs. This burcsella, baroque-like roof structures of Győr well adaptable to the evolutional structure development process of historic roofs are above the medieval, renaissance and early-baroque walls of buildings among the late medieval, narrow alleys being near the medieval street-network appointed by the walls of the Roman fortress. The *specific physiognomy of Győr* is also due to the duplicity of the historical centre, the *scenery of the specially formed buildings, and roofs fitting to the built environment* of blocks cut by wide, square street-network closed among the walls of the fortress but also preserving and including the medieval alleys.

Thesis 10.a *(destiny and future of the historic roof structures and lofts)*

For deciding on the destiny and future of the historic roof structures the *solutions proposable* for experts, illustrated by real examples: *conservation* of the structure either conforming to the modified roof geometrical relations; authentic, particular or overall *anastylosis* made by using the original elements; particular or overall *reconstruction* in accordance with the authentic discovery the original roof geometry and structure-construction; *building of a new roof structure* following the original structure operation or reminding the original roof form.
Solutions for functional change: external and internal *introduction* of the renovated, reconstructed or modernized roof form, and structure; *building* the loft in, and its *utilization*.

III. Final considerations

The real measure of value of every dissertation is the usability and usefulness of its results. If the academic publication, and practical information had already been published or planning to be published in the future in connection with this work, help for the current and future experts dealing with historic roof structures to orient in this subject, if they help to *feel and transmit, and save the historic messages of these structures, and if they help to preseve them authentically*, then this work will not be aimless.

IV. Publications of the projects of historic roofings and structure diagnostics

Books

1. *Épültdiagnosztika I. (1997)* (Handbook and manual for the building maintainers and operators of MÁV)
   Budapest, MÁV Ingatlankezelő Kft. p. 256
2. *Tetőszerkezetek A-tól Z-ig (2003) (*2004)[1]
   (Comprehensive practical handbook for designers, and executers)
   Chapter 4.2.6 Történeti tetők szerkezetfejlődése (pp. 1-2)
   Chapter 4.2.6.1 (pp 1-2.) Chapter 4.2.6.2 (pp 1-2.)
   Chapter 4.2.6.3 (pp 1-2.) Chapter 4.2.6.4 (pp 1-4.)
   Chapter 4.2.6.5 (pp 1-6.) Chapter 4.2.6.6 (pp 1-2.)
   Chapter 4.2.6.7 (pp 1-4.)
   Chapter 4.2.7 Történeti tetők statikai modellezhetősége
   Chapter 4.2.7.1 (pp 1-2.) Chapter 4.2.7.2 (pp 1-2.)
   Chapter 4.2.7.3 (pp 1-2.)
   Chapter 4.2.8 Történeti tetők szerkezet-komplexitásai
   Chapter 4.2.8.1 (pp 1-4.) Chapter 4.2.8.2 (pp 1-6.)
   Chapter 4.2.8.3 Történeti fatetők ácskötései (pp 1-42.)
   Chapter 4.2.9 Történeti tetők állapotváltozási sajátosságai (pp 1-2.)
   Budapest, Verlag Dashöfe
   (chapters made for the publisher's request) totally: 80 pages L

Articles

1. *Ácsolt fedélszerkezetek fejlődésének szakirodalmi vetületei és történeti megközelítése győri barokk tetők felújítása kapcsán (1998)*
   Magyar Építőipar Nr. 11-12. pp. 319-325 L.
2. *Építési hibák – hibaokok (2000)*
   Magyar Építőipar Nr. 11-12. pp. 351-358 L.
3. *Történeti fatetők szerkezet- és működéselemzése a fenntartás és felújítás szolgálatában (2001)*
   Magyar Építőipar Nr. 9-10. pp. 280-288. L.
4. *Historic roof structures (2002)* Hungarian Electronic Journal of Sciences (http://heja.sze.hu) – June 12, 2002.
   Architecture Section HU ISSN 1418-7108: HEJ Manuscript no.: ARC-020610-B 13. p. L
5. *Történeti fatetők szerkezet-komplexitásai (2003)*
   Magyar Építőipar Nr. 3-4. pp. 108-117. L.
6. *Megmentett, feltáruló, hasznosuló történeti tetőtereink (2003)*
   Magyar Építőipar Nr. 7-8. pp. 226-234. L.
7. *Gótikus jellegű ácskötések elemzése, példái 2003*
   Magyar Építőipar Nr. 9-10. pp. 259-266. L.

Lectures published in international conference-issues

1. *Tetők formavilága, szerkezetfejlődése (1998)*
   Széchenyi István Főiskola Jubileumi Tudományos Konferencia
   Győr September 21, 1998. pp. 25-34.
2. *Tetőszerkezetek szakmatörténeti elemzése (1999)*[2]
   (Trade specific analysis of roof constructions)
   23. Vedecká Konferencia Katedier a Ústavov Konstrukcii Stavieb
   Gerlachov (Vysoké Tatry) May 13-15, 1999 pp. 93-101. L
3. *Történeti tetőszerkezetek (1999)*
   XXIV. Épületszerkezettani Konferencia
   Győr May 26-28, 1999 pp. 97-103.
4. Attila Koppány, György Fátrai*: Új épületdiagnosztikai módszer és hibaelemzés az épületfenntartás és rekonstrukció szolgálatában. New Building Diagnostic Method and Failure Analysis in the Service of the Building Maintenance and Reconstruction 2000*[4]
   LEONARDO DA VINCI PROGRAM (VICCE – TOVÁBBKÉPZÉS AZ ÉPÍTÉSI VÁLLALKOZÓK VERSENYKÉPESSÉGÉNEK NÖVELÉSÉRE)
   (authorial rate: 50 %)
   Kolozsvár November 23, 2000 pp. 105-112. L
5. *Történeti fatetők gótikus jellegű ácskötései (2003)*
   XXVIII. Épületszerkezettani Konferencia
   Baja May 28/-30, 2003. pp. 4-16.

Notes: 2. in Hungarian with an abstract in English
4. both in Hungarian and English

Total number of publication *in this subject*: 14
Number of proofread publication: 10

(All publications of the author – today 50 – can be found on www.sze.hu/ep/arc)

References for the academic publications of the author in the given subject:

1. 36/2000. (MÁV Ért. 14.) PHM. Ig. sz. utasítás a D. 62 sz. az épületek és építmények felügyeleti tevékenységeinek ellátásáról. MÁV Rt. Értesítője, 2000. Nr. 14. pp. 1177-1186.
   Text:
   ”C: Épületdiagnosztikai kézikönyvek jegyzéke:
   I. Épületdiagnosztika I. (Author: György Fátrai)
   Published by MÁV Ingatlankezelő Kft. Budapest 1997.”
2. *Történeti fatetők szerkezet- és működéselemzése a fenntartás és felújítás szolgálatában (2001)*
   Magyar Építőipar Nr. 9-10. pp. 280-288. L. referred by
   Németh László: Faanyagok és faanyagvédelem az építőiparban 2003. p. 125.
   (editor: László Németh)
   5. A faszerkezetekről (authors: Károly Bátky, Dr. Attila Nagy) Budapest, Agroinform Kiadó és Nyomda Kft.
   Text (p. 119.): *“5.1-4. ábra Középkori tetők erőjátéka (Fátrai, 2001)”*
3. *Építési hibák – hibaokok (2000)*
   Magyar Építőipar Nr. 11-12. pp. 351-358 L. referred by
   Molnárka Gergely: Fuzzy halmazelméleten alapuló szemrevételezéses épületdiagnosztikai szakértői rendszer 2003
   Magyar Építőipar Nr. 9-10. pp. 288-292. L.
   Text (p. 288.): *“Az építési patológia az épületek és épületszerkezetek károsodási folyamatainak elemzésével és a megelőzés, elhárítés lehetőségeit feltárva egyrészt a diagnosztizálást segíti, másrészt a terápia, a rekonstrukció szakszerű elvégzéséhez elengedhetetlen eszköz.”*

“This way the time will come when not only
structure engineers will treat the wall paintings
or painted wooden furniture respectfully,
but architects and art historians
will also acknowledge the aesthetic value
of structural conceptions.”

(Bálint Szabó)