Ordination Architecture Analysis: Calculation of Proportionality of Order Form Elements

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Abstract. Architectural ordination is part of the theory of architecture dating back to antiquity but in many ways distorted today. The generalization of approaches to it gives two directions of research, namely, abstract (the search for universal laws of proportionality) and empirically-specific (the analysis of the proportions of an individual object). Adhering to the second approach, the author develops his own version of ordination analysis based on major-minor ratios. The calculations are confirmed by the results of measurements of buildings of different epochs and tested in the design practice presented in the article. Objects created on the basis of the theory of ordination can belong to different styles, but, undoubtedly, harmonize the human condition and the urban environment.

Key words: architecture, harmonization, ordination, proportioning, architectural order, major-minor order, proportionality, system relations.

1. Introduction

The need for a harmonious subject-spatial environment refers to basic human needs. As urbanization progresses, this environment becomes increasingly discrete and chaotic, disfiguring the environment, leading to mental and visual stresses. One of the possible forms of harmonization is the classical architecture, the harmonizing effect of which is generally recognized. However, the existing pluralism of architectural formation has put an in-depth study of the theoretical foundations of classical architecture, in particular, the concept of ordination, to the periphery of professional knowledge.

At the same time, the use of forms of style architecture based on order principles still stays at the forefront of modern architecture. Both at the beginning of the XIX, XX centuries, and at the beginning of the XXI century, architectural classics were again updated in the works of modern architects responding to social and aesthetic inquiries. The requirements of modern developers and customers to the quality of theories and pre-design concepts found out that most outstanding authors of treatises on the rules of orders essentially took separate chapters from Vitruvius as a theoretical basis and considered the correct graphic representation of samples in the system of scales devised by themselves to be the basis of the rules [11; 28]. We believe it is necessary and possible to overcome such narrowness and develop the theory and practice of proportionality of order forms. Therefore, along with a theoretical search, the article presents the results of its design testing by the author of the article.
2. Methodology

Despite the fact that the concept of the whole as a system of forms with diverse connections, has long been rooted in aesthetics and related branches of knowledge, architectural theory has not developed this issue within its disciplinary boundaries.

Starting with Vitruvius, then L. B. Alberti, J. da Vignola [11], A. Palladio [22] and their followers [3], the proportionality of the main parts of the order is declared, but not disclosed. The founders do not go further than stating the most stable ratios of column height to entablature height, column height to architrave height and other paired comparisons. Moreover, they are different for different authors. O. Choisy [8], V. P. Zubov [32], G. N. Emelyanov, A. G. Gabrichevsky, and others paid attention to this. The diagram of the dependence of the height of the architrave on the height of the column, illustrating the linear relationship between them [8] is well-known. In the comments to the treatise of G. S. Lebedeva [19] provides various statistics of dimensional relationships of cornices, architraves, friezes, columns, intercolumnia, for different buildings and authors, comparing them with each other but not trying to find common roots of proportionality parts of any particular order.

Professional literature, one way or another covering the problems of linear relations of order forms, is colossal in its scope (for a bibliography, see [29]). It is possible to distinguish two main wings of interest to us. Proponents of the first position continue the Renaissance-Classicist tradition and approach the study of the subject of proportioning more abstractly trying to deduce universal laws. These include R. Wittkower [30], A. Zeising [31], S. Colman [10], J. Hambridge [16], V. P. Zubov [32], V. Radzyukevich [23], L. I. Taruashvili [25], I. S. Shevelyev [24]. Other authors come from empirical data, studying specific objects of architecture: O. Balakshin [2], M. Ghyka [14], Ch. B. McGrew [21], K. N. Afanasyev, writing about Old Russian architecture [1], N. I. Brunov [5] and [6]; [20]. Our work was carried out based on the second, concrete empirical approach.

Let us note the connection of the scientific interests of specialists in proportioning with the stylistic processes of the second half of the XIX (Europe) and the 1930s (USSR), while we, above all, are interested in the possibility of using knowledge of proportions to create a stable, harmonious living environment in modern cities. The relevance of research on the problem is proved by the materials connecting the searches of the XVIII, XIX centuries with modern architectural processes [7]. The direction connecting the process of architecture and music is promising [12; 13; 27]. The proposals by L. Krier on the optimization of the urban environment based on the idea of proportions are interesting [18].

The difficulty lies in the fact that, in the presence of the work of the proportionalists abroad and in Russia, the traditions of the support of a particular object have been lost. It is not by chance that M. Cohen wonders where proportional studies disappeared, the peak of which falls in the middle of the XX century [9]. It was the absence of specifics that made possible the discussions of the type that the supporters of Renaissance views R. Wittkower and Le Corbusier, who relied on the Fibonacci series, led on the theme of divine proportion [17].

Moreover, attempts to identify the consistency of the linear relations of individual elements of the order were made based on minor-major relations. For example, G. D. Grimm (1865–1942) constantly used minor-major relations when analyzing the proportions of orders and their parts, including when analyzing the modern architecture of the 1930s [15, 123–135]. However, these were minors and majors derived from the “golden section” relationship, and not from the minor-major order peculiar to a specific order or construction. Naturally, the proportion alien to a particular subject could not clarify anything.

In general, there are no works in domestic and foreign architectural science explaining the system’s linear relations of order form parameters and their parts, taking the main order values inherent in a particular order, the order height and column height, or their derivatives. Meanwhile, their correlations are easily determined through measurements, absolutely visual and individual for each architectural object. It is in this direction that we go in deciphering proportionality and building the whole and its parts using the method of architectural ordinates and the theory of initial linear relations developed and tested by the author in the projects of 2016–2018: correction of the facades of the Tour Theater in
V. Pyshma, Sverdlovsk region; the project of the church in V. Pyshma; the development of facades of Sandunovskie baths in Yekaterinburg; Cathedral in Honor of the Resurrection of Christ in the city of Kokshetau, Kazakhstan, etc.

3. Results

During the study, we obtained two types of results, namely, measurement-computational and design-architectural.

Ordination analysis was carried out to study the peculiarities of the major-minor order based on the images of orders contained in the sources and their full-scale survey. It allowed us to collect and systematize many previously separated data. These are graphic representations of orders in the treatises of A. Palladio [22], J. Da Vignola [11], H. Blum [4], A. Desgodetz, F. de Chambray and others.

From the author's measurements, the dimensions of the building and porticos of the Corinthian order of the Alexander Nevsky Cathedral of the Novotikhvinsky Female Monastery (Yekaterinburg, mid-XIX century, arch.: D. Visconti, I. Charlemagne), as well as measurements of the bases and pedestals of the Vienna classicist buildings (Figure 1): Austrian Parliament (arch. T. von Hansen); University of Vienna (arch. H. von Ferstel); The Vienna Opera (architect S. von Sicardsburg); buildings of the imperial museums (architect G. Semper and C. Hasenauer); Karlskirche church (arch. J. B. Fischer von Erlach) and others have been analyzed.

![Figure 1. Examples of measurement bases and pedestals of historical buildings of Vienna (photos by A. V. Dolgov).](image-url)

Author's developments were tested in the design of a number of objects, both classical and modern (Figures 2, 3). Patterns found in the course of the study are capable of practical implementation, and this is the main result of the study.

4. Discussion

Studies by the author’s method of ordination analysis allowed proving the proportionality of the linear parameters of the basic elements of orders and the forms derived from them, linking them with the simplest mathematical formulas following up the author’s theory of initial linear relations. As a result,
it was determined that the formulas of proportionality of the linear parameters of the order and its parts are similar to the system of relations arising from the arbitrary division of a segment into two parts: larger and smaller (major and minor). That is, the linear parameters of order forms are subject to the laws of the minor-major order, forming coherence according to dimension – the harmony of unity of the plurality of forms.

Figure 2. Cathedral in Honor of the Resurrection of Christ. Kokshetau, Kazakhstan. 2016–18. Arch. A. V. Dolgov. Author's photograph.

Figure 3. The main proportional relations on the southern facade of the Cathedral in Honor of the Resurrection of Christ. Kokshetau, Kazakhstan. 2016–18. Based on the proportions of the "golden section". Drawing of A. V. Dolgov.
All classical orders possess coherence according to dimension, showing this quality in one, two and three-dimensional spaces. At the same time, the linear parameters of the forms that constitute architectural orders are in correlation relations, that is, a change in the value of a parameter entails systematic changes in the values of other parameters.

The degree of such a correlation may be different, especially in architectural practice; however, in theory it is possible to create architectural objects (bodies) with a very high degree of correlation. Such, for example, are architectural orders. In addition to these, high correlation properties have been established in a number of antique buildings, in the first place, the Parthenon [12].

4.1. Notions «major» and «minor» as basis of ordination analysis

These facts point to the inherent independent linear system of order forms, which goes back to the ratio of the multiplicity and difference of the main major (height of the order) and the main minor (height of the column of the same order). The system is not subject to external imperatives, for example, the "golden section" (unless it is the main order ratio). The dimensions of a major and a minor originate from the arbitrary division of the segment \(A\) into two parts: \(M\) – greater (major) and \(m\) – smaller (minor), i.e. \(A = M + m\); also we allocated a value \(\Delta = M - m\).

In the course of ordination analysis of architectural forms, these quantities serve as indicators showing the presence of linear dimensions in the analyzed form, related to each other similarly to the ratios of the initial linear quantities. This refers to the pair ratios of the multiplicity and difference of \(A, M, m, \Delta\) between themselves.

If there are quite a few such ratios and differences, this indicates the dominance in the horizontal and vertical dissection of the architectural form of a certain general structure, expressed in repeatability at different scale levels of the same ratios of the linear dimensions of the elements of architectural forms.

It has been established that the comparison of the height of the entire order (\(M\)) with the height of the columns (\(m\)) appears most clearly in the order composition. We called it the main order ratio \(M : m\), where \(M > m\) always.

Calling \(M : m\) the main order relation, we recognized that it is the whole order structure that depends on it, therefore, it can be defined as a major minor order.

On the basis of the concepts highlighted, an ordination analysis of the classical architecture can be carried out, in order to then use the knowledge gained in modern architectural practice. We present below one of the options in order to give an idea of the main steps and results.

4.2. Ordination analysis of the Theater of Marcellus in Rome using the major minor approach

The building was built in 12 BC and gives an example of a Doric order (Figure 4). Characteristic divisions according to type 1:

- along the top of the architrave: a) architrave with a capital (\(m\)), frieze with a capital (\(M\)), b) architrave (\(m\)), triglyph (\(M\));
- height of the capital (\(M\)) and architrave (\(m\));
- cornice (\(m\)) and frieze (\(M\));
- echinus with annulets (\(M\)), neck of a capital (\(m\));
- width of the taennius architrave (\(m\)) and the trigriff globule (\(M\));
- capital abacus plinth (\(M\)) and abacus cornice (\(m\));
- and other divisions.

Characteristic divisions according to type 2:

- cornice height (\(\Delta\));
- height of the supporting elements of the cornice (\(\Delta\));
- height of abacus cornice of the capital (\(\Delta\));
- astragal fascia height with fillet (\(\Delta\));
- other horizontal divisions.
Similarly, we analyzed the architecture of different orders, gradually accumulating empirical data on ordinal relations.

4.3. Universality of major-minor design
Measurements and design confirm the presence of minor-major pair relations that arise when the order forms are divided into parts, in the overwhelming majority of cases. At the same time, within a particular object (order), subordination to the constant relation $M : m$ is maintained.

Dimensional relationships exist because in each order and its fragments we constantly find various combinations of minor-major variables: $A, M, m, \Delta$.

It is characteristic of such combinations that the same dimensions, fixing the dissection of order forms, can appear in different qualities. For example, $\Delta$, being the height of the entablature obtained by cutting off the height of the column $m$ from the height of the order $M$ when the height of the entablature is divided into parts, also acts as $A$ (thus, we can determine the characteristic lines of the average separation of the entablature), and as $M$ (thus, we can determine the cutoff position from the entablature plate), and as $m$ (thus, we can search for the pair measure to «om» outside the entablature; as a rule, it turns out to be some important part of the capital of the column, or the entire height of the column).

Consequently, in the major-minor structure, characteristic of order forms, we find that the same value can be divided many times, using ratios similar to those of the initial linear quantities. At the
same time, all such divisions of the form will consist of a set of segments included in the major-minor order. There may be an infinite number of their combinations, but these will be combinations of the values established by the major minor order.

5. Conclusions
As a result of the study, both partial and general patterns of organization of order forms were identified, some of which are stable and repetitive in nature; it has been found out that these patterns serve to harmonize order forms among themselves in a single order composition; it is confirmed that, knowing the essence of sustainable forms, their correlations and combinations, an architect acts more meaningfully and is able to create new compositions of not only order but also of abstract nature.

The analytically determined properties of linearly independent systematics of the parameters of order forms were not previously known. Their further revelation requires expanding the scope of research on the study of linear plane and volumetric parameters of real architectural objects, which will deepen the understanding of the principles and mechanisms of harmonization of sets of various forms subordinate to the laws of linear systems of architectural orders and can radically change ideas about the role of formative order patterns in architecture.

The completed studies confirmed the prospects of this area of work related to the return to the theory and practice of modern architecture of knowledge and skills on the fundamental principles of the organization of architectural forms, known in antiquity and currently lost, which is designed to significantly improve the aesthetic qualities of design and deepen the understanding of architectural advantages of historic buildings and structures.

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