Appraisal of Heritage Buildings in the Post-War Period in Bosnia

Amir Čaušević¹, Lemja Akšamija¹, Nerman Rustempašić¹, Dženis Avdić¹
¹University of Sarajevo, Faculty of Architecture, Bosnia and Herzegovina
nermanr@af.unsa.ba

Abstract. The unexpected loss of values, as one result of the total destruction during the armed conflicts and war, put us on the challenge to properly decide about methods of rehabilitation, and integrating and understanding values and actions that could vary from restoration to, in many cases, even full reconstruction. During the 1992-1995 war in BiH, many valuable assets of cultural heritage like national monuments, historical places, and historical structures were damaged and/or destroyed. After the aggression, the first step has been to regain and/or establish the function of the places destroyed, while for the cultural heritage assets these attempts called for the approaches more careful. It is not only that the importance or the significance of places and structures destructed is different, the level of destruction also is. These inputs are essential in having preparedness for any action when without possibilities to rely on unique methodology. Even though is now 20 years after the conflict, Bosnia is still faced with the post-war recovery efforts, with problems newly occurred that are the outcomes of unsuccessfully implemented methods of rehabilitation. This paper aims to present an overview of the interventions implemented within Bosnia and Herzegovina given in respect to the typology of a building, its importance including intangible values and the level of its destruction. Giving examples of Ferhadija/Ferhat Pasha Mosque in Banja Luka and the Old Bridge in Mostar – the examples of total reconstruction, will guide one to understand aspects of choosing the reconstruction action as the appropriate intervention. There are also valuable examples of post-war recovery and rehabilitation for the historical places, such as is the Old town of Počitelj with its entire valuable structures, where after the urban reconstruction – we now have the new challenge of managing the historic place. The inside view shall be more oriented on the case of the Handanija Mosque in Prusac where correct methodology approach had been applied regarding the diagnostic, identifying and/or determining the nature and causes of damage and deterioration of the facility through the inspection and examination, but some rather improper conclusion and decision have been derived from that investigation works. In addition, some analyses of Index of shifts of minaret have been conducted too. Index of shift represents the relation of minaret height – h and width of its layout (D or 2r) or the diameter of circular cross-section. Analyses of conducted work could provide us with a better understanding of the damaged buildings potential weaknesses and weak spots. Reinforcement and strengthening of damaged construction structure has been among the most important tasks. In some cases, improper interventions on heritage structures may have been damaging - in sense of impairing the authenticity, while sometimes it was an insufficient knowledge on structural behaviour and the materials used in historic structures that brought unexpected additional damages. The use of traditional crafts, techniques, and materials is one of the most important elements in the process of architectural heritage protection, contributing to the adequate protection, restoration, conservation, as well as its maintenance.
1. Introduction
For every building, it can be said that the degradation starts in the very process of its construction. What we consider as important to be highlighted is the fact that the architectural heritage in Bosnia and Herzegovina suffered unrecoverable damage in the period from 1992 to 1995, during the war in country. The philosophical question posed to think about is – whether it was collateral damage or was it intended and premeditated demolition of the heritage. Taking into account that Annex 7 to the Dayton Peace Agreement, which elaborates on the return of the refugees, liaise with Annex 8 – which tackles the issue of the cultural and historic heritage demolition, we can then speak about erasing the memory of a given site, which separates people – as the spatial beneficiaries, from their memories, emotions, and notion of belonging to the certain space/spatial setting. From the perspective of now, respecting the rules of the profession, the only thing that makes sense is to successively reconstruct and regenerate the heritage, through a process founded in scientific principles of conservation and protection, and in line with international charters and the conventions on the protection of cultural goods/assets, an exercising the identical approach for all the historical levels and layers, considering and validating all of them equally.

A waste number of monuments got demolished or significantly damaged in the given period so it can be understood why it has been reached out for the new methods which, thanks to the documentation available, enabled for the heritage restoration from the first moment of its feasibility. Current legislation that we rely upon, which accurately speaks of experiences of conservation and restoration practice so far, with established postulates of protection of the architectural heritage, which through the use of restoration as recoupment for the missing, also mentions the reconstruction in cases where heritage structures are abruptly destroyed due to war or natural disasters, which is considered instantaneous degradation. Declaration of the General Assembly of the Europa Nostra Organization, adopted in Vienna on 25.04.1996, speaks of this issue and reflects the position of the EU, the UN and the Council of Europe, which insist on the restoration of the architectural heritage, and explicitly highlights protection and restoration as well as reconstruction of various phenomena where religious and ethnic monuments were destroyed and damaged.

The preamble to the Hague Convention, among other things states: “...that any damage to cultural property, irrespective of the people it belongs to, is a damage to the cultural heritage of all humanity, because every people contributes to the world's culture ...”1 To the great disappointment, the Hague Convention, at this area and in the period of war activities harming and affecting both people and facilities, remained at the level of empty legal documents. Given the complexity of the process of protection, which tackles upon not only the physical restoration of structures of buildings and complexes but also returning the identity to a general space and its users, meaning the historical restoration of the heritage, people customs in the unique ambience where one meets with the integral heritage, the process, led by the idea from the declaration on the reconstruction of war-torn buildings, runs in a way that - through active protection, we contribute to emphasizing the continuity of spatial relations. This is the only possible way to perform the substitution of buildings in places where old buildings once existed without compromising the integrity of the urban matrix while retaining the value that can be considered as the value of an ambience. To have the standing point and opinion about this issue is to define this evolutionary process of protection in the way so as to prevent the creation of new facilities that by their spatial expression do not take into account the previous values, and that with the reconstruction following we suggest that by building in the style of predecessors or literally transferring physical values with the documentation, we contribute to the retention of ambient values. In cases where we lack adequate documentation, building with stylish and ambient reminiscences we can still retain the spirit of the place while emphasizing the spirit of the nowadays.

1An excerpt from the preamble to the 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict
2. Historical values and safety

Monuments are precious objects that ought to be respected and altered as little as possible. These observations could lead to contradictory decisions, at times accepting a higher degree of risk in order to avoid or limit alterations to the original concept. This conscious respect for the tradition stood as an obstacle on the way of eliminating the risk.

The term restoration carries the notion of hair-splitting work. Slow restoration process would allow the community to heal and reconnect with the monument, but it also provides time for the technical and building aspects to regain the quality of the original. In that case the evaluation of authenticity of heritage property can now be increased through the quality and uniqueness of the restoration process.

All historic buildings have undergone some modifications in their lifetime. These modifications were alternating performed with periods of relative inactivity and negligence. Typically, minor repairs were carried out periodically. Maintenance, renovation and modification are usually performed occasionally. There is, of course, constant pressure to some values and contributions that heritage makes to society. It is impossible to lay down rules for choice on the intervention type although certain guidelines can be provided – such as respecting the original conception and achieving a skillful balance between the safety and the necessary permanence, in line with the minimum intervention philosophy and a careful assessment of the possibilities offered by both the old and new technologies. But then again, physical protection is not enough in order to have permanently preserved monuments. We must be aware of what is coming next, what kind of influence will, during usage, affect monument.

3. Calculations method for masonry structures

Structural analysis is yet another significant tool, currently widespread and appreciated in the diagnostics phase. It requires contemplating and taking into consideration aspects like geometry and the morphology (structural form, internal ingredients, bonds among and between the structural elements, etc.); properties of the materials; activities and impacts (mechanical, physical, chemical, etc.); alterations already in place and damages present (cracks, constructive faults, breakups, crushing, tilting, and similar); and the interaction between the structure and the soil (except in cases when it can be considered irrelevant). Valuing the structural safety of historic masonry towers, following the principles of heritage conservation, is one of the central issues in maintaining national and world architectural heritage. Engineers are required to expertly balance the safety and required duration of the facility, following the original concepts and following the minimal intervention philosophy. The conceptual process of analysing structure, in order to understand, define, quantify, and visualize the structure of an object observed, and to simulate the effects of different actions is called modelling. To manage in presenting the current situation, the model is a necessary approximation and it represents a limited number of the most significant impacts, all in order to achieve a sufficiently accurate solution. Given the difficulties of this process, which implicitly involve concepts and hypotheses about actions, or mechanical, geometric and morphological properties, no model can accurately describe the real state to the end, the engineer is always asked to calibrate and validate it.[1]

Based on observations and empirical or experimental information, it is an iterative procedure for hypothesis testing that is usually adopted. Only when the process is completed, i.e. when the results correctly simulate observation, the model can be used to make safety predictions and for evaluation of the intervention measures. Only recently the structure got identified to be a separate segment of a monument and a cultural asset on its own that possesses valuable documentary value. As a fundamental part in some 10000 years old history of building works, which can be matched with the history of civilisation itself, the structure is to be preserved as if it was precious yet still a running documentary and a testimony of the construction and building skills of our ancestors.

Finite element method – Not applicable – the collapsed structure undergoes large deformations and the emergence of discontinuity is not possible.
Mesh free methods – Suitable for large deformations, but have less computation efficiency and accuracy than the FEM.

Discrete element method – Suitable for collapse analysis of masonry structures, but needs prior discretization and defined location of potential cracks.

4. Inadequate interventions on architectural heritage structures

The architectural heritage is distinctive for its enormous capacity of traditional knowledge, layered and accumulated through centuries and, which if correctly read and interpreted gives a great deal of information about the construction, materials and technologies that have been used over time. Failing to properly interpret that knowledge has its consequences, namely inadequate interventions. Such consequences are still visible; some from earlier times, when there was no awareness of the architectural heritage, but unfortunately also in recent times, when the architectural heritage got further degraded and not adequately valorised. Besides many earlier listed causes of the decay of the building materials and constructions, the additional degradation of structures also gets inflicted by inadequate interventions on the architectural heritage structures, which in most cases implies: the use of inadequate materials for interventions on the bearing structures and the structural system as a whole (stone, brick, mortar, wood, metal, etc.); misinterpretation of the structural assembly; inadequate recipe and types of binder materials; inadequate and redundant use of concrete; inadequate and improper setting of new installations; inadequate technologies used during repair interventions and reconstruction; inappropriate upgrades in protected structures and units, and an inadequate protection of embedded materials in load-bearing and non-load-bearing structures. [3]

5. A maintenance program

This is a support for the owner/caretaker of a historically valuable building in regard to the ownership and the daily maintenance. It describes “What to do and How to do it”, and it shall be done and revised by a professional architect in cooperation with the owner.

5.1. Preservation

The use of traditional crafts, techniques and materials is one of the important elements in the process of the built heritage protection, contributing to its adequate protection, restoration and conservation, as well as maintenance. Traditional crafts used in the restoration of historic buildings were facing the threat of extinction and that they should be supported. A full understanding of the structural and material characteristics is required in conservation practice. Information is essential on the structure in its original and earlier states, on the techniques that were used in the construction, on the alterations and their effects, on the phenomena that have occurred, and, finally, on its present state. When a historic structure is substantially damaged, to fully restore its physical appearance requires more than just correctly chiselled stone blocks; restoration needs to (re)establish the connections to its context, past glory and present meaning in the community. Some of the existing documentation shows the records on each stone and all the cracks and the imperfections – which has been an essential tool in making decision to undertake more extensive interventions in order to restore the structure. In order to restore and mend previous interventions of lower quality, the restoration process demands stone by stone dismantling and re-composing of some parts of a given structure. Not only single restoration method but the sublimation of the assemblage of all of these specificities on materials, details contribute to the future practice and education of the professionals. [3]

6. The BiH Experience

6.1. The Old Bridge; Mostar

Old Bridge, also known as Mostar Bridge, is a rebuilt 16th-century Ottoman bridge in the city of Mostar in Bosnia and Herzegovina that arching across the Neretva River connects the two parts of the
city. The Old Bridge stood for 427 years, until destroyed on 9th of November 1993 during the war. Subsequently, a project was set in motion to reconstruct it; the rebuilt bridge opened on 23rd of July 2004. The reconstructed Old Bridge and Old City of Mostar are on the UNESCO World Heritage List. The Old Bridge/Stari Most is hump-backed, 4 metres wide and 30 metres long, and dominates the river from a height of 24 m. Two fortified towers protect it: the Halebija tower on the northeast and the Tara tower on the southwest, called “the bridge keepers”. [2]

![Figure 1. Stari most/The Old Bridge –views and layout of the scaffold for reconstruction of the stone arch of the bridge [2]](image1)

During the reconstruction a special issue was the question of the scaffolding setting due to unpredictability of the river flow and an insufficient experience in building stone bridges of this span. Steel truss construction has been placed on special concrete pillars built on stone riverbank and additionally wedged. The steel grid has supported wooden arched formwork on which the stone blocks, of total weight over 300 tons, were arranged.

The bridge is built in local “tenelija” stone (grainstone), which is a local name for Oolitic limestone which has been exploited from the nearby Mukoše quarry for centuries. The stone is very light (only 2 tons per cubic metre [m^3]) and porous, while resistant to freezing. It is very easily worked into the desired form, which we have witnessed during a visit to a separate place where diligent Turkish stonemasons hand-worked the prepared stone blocks, as their predecessors 450 years ago would have done. After the remains of the arch had been retrieved from the river and dismantled, it has been confirmed that all the blocks were connected by wrought iron cramps and the cramped section sealed with lead, which is a soft and workable material, softer than wrought iron and harder than tenelija stone (grainstone/Oolitic limestone), and it completely fills the holes in which it is poured, and at the same time, like other metals whose temperature fluctuations are very dangerous, does not damage the stone into which it is trapped. The rows were interconnected by means of iron wedges in the middle plane of the arch, and with five rows of iron clamps at the extrados surface. The arch of the Old Bridge is fully reinforced stone construction.

![Figure 2. Presentation of arranging and bonding of stone blocks into arched bridge construction [2]](image2)

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3Oolit–carbonate sedimentary rock predominantly composed of ooids.
6.2. The Handanija Mosque, Prusac

The Handanija Mosque was built in 1617. The year is still visible on the chronograms positioned above the front door and above the harem gate surrounding the mosque. The mosque is named after its founder, Handan-Agha, a wealthy Ottoman official (Handan-Agha’s, Handan-Bey’s, Handanija Mosque). His tombstone is still visible in the harem behind the wall with the mihrab/the Qibla wall. The building is set at central position in the village, not far from the medieval fort on a nearby hill. It is the starting point of an annual pilgrimage known as the Ajvatovica. The mosque has historically been the centre of cultural and religious life in Prusac.

The restoration of the Handanija Mosque was started in the summer of 2003 with the building project documentation. An essential part of the mosque's restoration was to initiate the project documentation assembly process, including measuring the mosque, documenting the damage, studying and collecting historical data from books, archives, old photographs, etc. The loose fragments found were mostly parts of a ruined minaret, holes in the wall and door jambs.

The mosque has a square base of dimensions 16.30 m x 12.70 m, with a minaret partly built into the southeast wall. The whole structure is built in four types of limestone stone, all of which have been whitewashed and plastered (except for window architraves). This is the only mosque in Prusac with a stone minaret. The complete minaret is built in tufa.

The Handanija Mosque was damaged in 1993. Due to several direct hits by shells, the building suffered severe damage to walls, roofs and minarets. The roof structure was completely destroyed, while the rest of the structure was badly damaged. The whole building was shaken. The displacements of several building elements were visible, especially in the minaret and on the walls around the windows. The higher parts of the minaret had to be dismantled. The vertical alignment was offset by 9 cm; there is no evidence on when exactly it occurred. Inside the minaret, there were three steps completely missing between rows XV and XVIII. The top of the minaret to the fourth row from the gallery was completely missing. The stone and the structure were exposed to the weather. The rest of the minaret suffered severe damage, with holes and cracks along the entire height. [4]

6.2.1. The Handanija Mosque, Prusac – Research results

In models were used known mechanical characteristics of materials utilised for minaret construction, according to data used in calculations in the project of reconstruction of the porch and minaret of the Handanija Mosque namely: modulus of elasticity of section without cracks, Poisson's coefficient and volume weight of stone material are 6,000,000 KN/m², 0.23, and 20 kN/m³ with variants of adherence and non-adherence to the building. Linear elastic behaviour of the material was also assumed, while the stiffness reduction was neglected. Second-order geometric effects were also neglected in the analyses. Attenuation with a viscous attenuation coefficient of five percent has been used for all dynamic analyses of the area. The minaret is known to be located in the region of moderate seismic activity, in Zone VII in accordance with the Bosnian regulations on earthquakes.
Figure 4. The Handanija Mosque 3D model cross-section floor plan [5]

Although the tensile stresses and compressive stresses are approximately symmetrical, the minarets are subjected to higher compression stresses in almost all cases, mainly due to the additional constant pressure load caused by the structural weight.

The study has shown that the effects of wind in the cases of tested variants of lower features and attributes of material, reduced element thickness, lack of minaret adherence and reduced minaret height are relevant both in terms of maximum displacements and in cases of extreme stress values.

6.3. Ferhat-Pasha’s Mosque, Banja Luka

The Ferhat-Pasha’s Mosque was located in the zone between Crkvine Stream (Crkvene) and Vrbas River, in the former Donji Šeher.

The Ferhadija mosque was built in 1579 by one of Ferhat Pasha Sokolović’s numerous donations. Most likely, it was one of Mimar Sinan’s students who expertly built Ferhat-Pasha’s Mosque, wanting to examine new constructional methods as an experiment and a prototypal facility before building Sultan Murat III donation in Manisa. Indeed, such a building could be the product of highly educated mimar (a constructor), and muhendis (an engineer) at that time.

Figure 5. Ferhat-Pasha’s Mosque; floor plans, and cross-sections [5]

6.3.1. Materials

Walls of the mosque and minaret are made of crystal travertine that is cream-white in colour. Travertine is a porous calcium carbonate rock that comes from sedimentation in cold water. Its important property is that it is resistant to frost. Since stone for the mosque rebuilding is to be excavated at the location where initially excavated, namely at Divčani near Jajce, we do not have data about mechanical properties of the material and for reference properties. During the calculations, data used are the same ones used during last rehabilitation of Ferhat-Pasha’s Mosque in 1986. After that, the mechanical properties got determined based upon three samples taken from walls with the use of “KERN” machine:

- Volume weight of the stone is approximately 20.00 KN/m³
- Resistance to pressure is average 1.28 KN/cm²
- Dynamic module of elasticity of material Ed=184000 N/cm²
Assumed values are as follows:
Stone wall: Allowed tension as result of pressure $\sigma_c=1.2$ MN/m$^2$; Allowed tension as result of tensing $\sigma_t=0.05$ MN/m$^2$; Allowed tension as result of horizontal stress $\tau=0.10$ MN/m$^2$; Module of elasticity $E=5000$ MN/m$^2$ [5]

6.4. Počitelj
Počitelj is a historic village of Oriental-Mediterranean character located in a natural amphitheatre on the left bank of the Neretva River, about 30 kilometres to the south of Mostar.

6.4.1. Šišman Ibrahim-Pasha Mosque
The parts of the mediaeval fort were incorporated into it and remain recognizable within the later alterations and additions dating from the Ottoman period. All that nowadays survived of the mediaeval fort is the lower part of the main tower, the small square tower to the left of the entrance to the fort and a part of the ramparts on the west of the cistern.

The Šišman Ibrahim-Pasha Mosque (also known as the Hajji-Alija Mosque), built in the 15th century, is located in the heart of Počitelj. The mosque is characteristic for being monumental and for its simplicity. Close to the minaret stands a Cyprus tree brought from Lebanon in the 15th century. The mosque in Počitelj was built by Hajji Alija Mujezinović, son of Musa-Agha, in 1562/63. This mosque is one of the models for the single dome mosques and this has a high octagonal stone minaret decorated with stalactite decor beneath the Şerefe. There is no cemetery next to the Počitelj Mosque, as is usual with other mosques in Bosnia and Herzegovina, because the harsh and cramped terrain did not allow the formation of a graveyard. The entrance to the mosque is adorned by a very beautiful carved double door, positioned under richly decorated portal.

Figure 6. Layout of the minaret with vertical development of one FRP strip and comparison among the real view and thermograms of the framed areas

6.4.2. Results obtained by thermographics tests
After determining the thermal contracts for the evaluation of the defects, a mosaic of partially digitally straightened thermograms was assembled in order to show the complete view of the tested element. Comparing the thermograms with the real view of the areas framed by the IR camera, a first localization of the defects is allowed.

7. Preservation techniques
It is impossible to give a rule for the election of the intervention, although certain guidelines can be provided, namely: respect of the original concept, master balancing between the safety and demanded durability, adhere to minimum intervention philosophy and careful estimation of prospects and possibilities given by the old and the new technologies. Utilisation of proven quality materials, already
tested, the ones that have high value tensile strength (carbon fibres, epoxy resins, SMAs, STUs etc.) that allow for fast, economical and efficient installation is always the desirable approach.

Selecting and integrating feasible techniques of intervention is a complex task – given that there several parameters that need to be considered. In order to facilitate a monitoring of administrating and managing the execution of such a task, a simplified decision-making procedure is proposed. The proposed procedure involves interconnected operations. This can be summarized as follows: establishing a mechanism for perceived or expected damage; adopting an appropriate intervention strategy designed to prevent or improve the response of the structure in view of the detected/determined damage mechanism; specifying concrete actions that are feasible to implement within the objectives of the envisaged intervention strategy. This process, by narrowing down the possible intervention actions that must be performed on the building, results in a simpler choice of a viable technique.

Some instructions and guidelines to be observed in cases of work on rehabilitation of historical buildings:

- Historical features of the construction functions shell be retained, or a new mode of utilisation shall be developed adhering to principle of minimum changes in the characteristic materials, features and characteristics, space and spatial relations, and avoiding making changes in the above mentioned.
- The changes performed that gained certain historical value shall be retained.
- Changes in historical features and characteristics shall rather be repaired than replaced.
- In case that the changes are of significant intensity and demand for removal of the existing parts, new parts must be a perfect match in regard to colour, design, texture, and if possible, in a material itself.
- In cases where a historical construction is a subject to chemical or physical treatments that cannot be avoided, those treatments are to be performed with maximum possible caution, and must never be applied in a manner that the treatment applied further damages or cause a damage to the structure/the building.
- Archaeological sites must be protected and preserved.
- The additions (upgrades, new parts of building), changes of the outer appearance or approved new constructions and structures must never damage or annihilate the historical material, the features and character of the building and characteristic set of spatial relations, meaning that if such new facilities would be removed in the future, the historical site/building would be left with its basic shape and its historic features integrity intact.
- It should be visible and distinct – what is new and what is historic.
- In cases where material is to be altered or changed, a compatible substitute material is to be found.
- Restoration of masonry structure walls by means of repair of mortar works is done in cases of destroyed mortar, cracks in knots, and wet walls with careful removal of damaged mortar in order not to damage the masonry.
- In restoration of roofing it is not recommended to remove much of the roof in order to rebuild it in new material in order to create a uniform or "enhanced" appearance. Appropriate anchorage systems for the roof structure should be provided to protect it from wind and moisture penetration.

8. Conclusion
The architectural heritage preservation and valorisation is becoming an increasingly important social and economic issue in many countries. Problems and challenges in this field range from defining and selecting the required level of safety, to methodologies that can be applied so as to perform reliable structural analyses and control safety and security, to selecting design and performing installation of appropriate materials and deploying intervention techniques aimed at repairing and strengthening the architectural heritage while preserving its cultural, historical, artistic values.
In the recent past, a number of efforts have been made to design specific tools for practicing engineers and architects to address the above issues appropriately: new generations of law and practice recommendations are also available, especially for historical structures, with particular reference to research activities, practical application and also the recent updates of legislative and the guidelines.

Finding technical solution for structure repair is much more complicated and work that demands dedication than it is to design a new object. The reason to state this is that very often some very important elements of structure cannot be determined before beginning of the intervention works; we are facing with the new and unknown, and data and information are being often discovered on the very site. A selection criterion has to be led not only by structural efficiency desire and being economically efficient, but also with the knowledge of techniques and technologies used in the construction of monuments, and by respecting original conception. This aspect, together with the part written in following paragraphs, always has to be present and visible in any project concerning preservation of cultural heritage.

Damage elimination is a primary requirement for the safety and durability of an object to be achieved, thus it must be performed in such a way that the facility, the building in question, is brought to a satisfactory state of safety and durability. Since in some cases the repair must be carried out with some materials that were not used in the original construction, such interventions must be carried out in a way that will deviate from the original as little as possible, and only if those do not alter the basic features and the character of the appearance and space of the facility and its ambiance. It is possible, if need be, to perform the operations on the foundations, underground, etc. The difference between reversible and irreversible interventions is that, in addition to minor common constraints, the irreversible interventions require additional compatibility of the new materials with the old ones, as well as their durability.

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