Manual

Archaeological Treatment of destroyed historical Monuments

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Based on the research report: "*SWD-10.08.18.7-17.50*"

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The authors are responsible for the contents of this manual.

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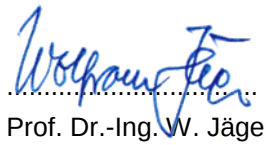

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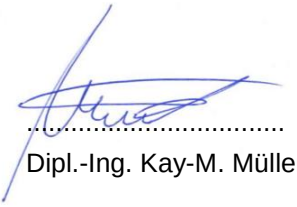

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1 Foreword and glossary

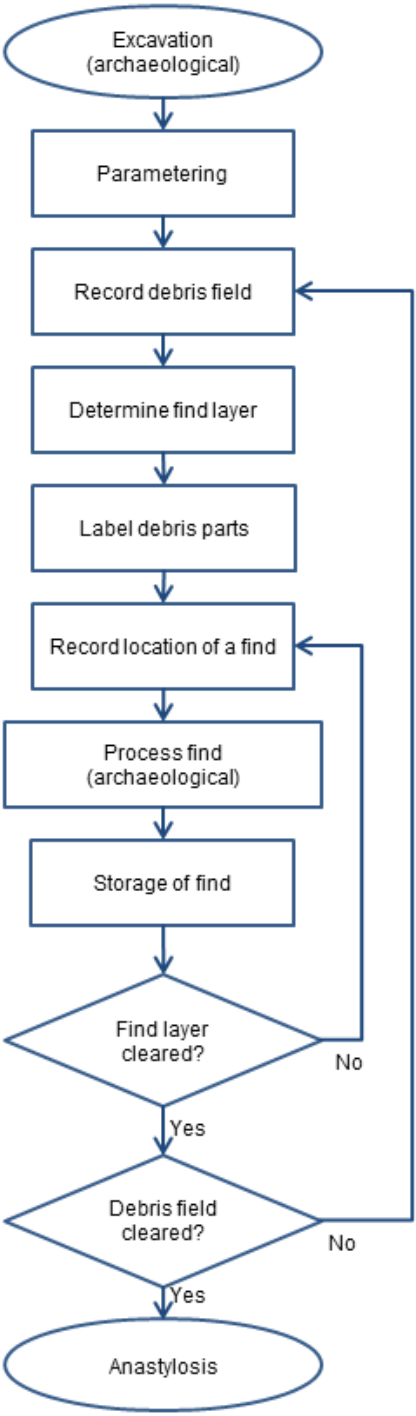
The world has an immeasurable treasure trove of archaeological sites and monuments that reflect the history of building. Natural catastrophes[1], wars[2] or human failure[3] have already damaged or destroyed many of these monuments. In order to make these valuable and occasionally iconic cultural treasures available for people to experience, it is important to lend this restorative challenge support by employing suitable instruments. Numerous insights regarding archaeological excavation work and the availability of the latest technologies can be combined to program a data bank management system. It permits the entire process of excavation to be supported by a modern computer system, an accompanying manual serving to list the requirements, personnel required and model solutions to solve the technological problems related to the finds. These problems range from location of the find to its reintroduction back into the original building.

Debris field	Area covered with debris
Debris mound	The entirety of the debris
Debris	Non-classified object
Find	Debris marked with find marker
Find situation	Observed and measurable find conditions
Find layer	The respective uppermost layer of the debris mound, that can be excavated without influencing the find situation of neighbouring debris
Excavation	Recovery/physical removal of all finds from the debris mound
Rubble	Material remaining after clearance

[1] Earthquake damage to temples and palaces in Kathmandu-Tal/Nepal, 2015

[2] Destruction of the triumphal arch in Palmyra/Syria, 2015

[3] Fire in the cathedral of Notre-Dame de Paris/France, 2019


Excavation (archaeological)
Parametering
Record debris field
Determine find layer
Label debris parts
Record location of a find
Process find (archaeological)
Storage of find
Find layer cleared?
No
Yes
Debris field cleared?
No
Yes
Anastylosis

2 Prospects

2.1 Set-up of a database

2.1.1 Requirements

- Registration of the measured grid and the individual grid squares
- Registration of the numbering areas for the find numbers, verification of the uniqueness (no number to be issued more than once, no find registered under several numbers)
- Find data must be capable of being entered, stored, edited and read out
- The data of the find location must be capable of being entered, stored, edited and read out
- The details of location of the finds must be registered via all processes (find, recovery, interim storage, fitting) and traceable without gaps
- Linking with and the assignment to other data sources (pictures, drawings, scans) must be ensured
- Storage management of the recovered and mapped finds

2.1.2 Required personnel

- Web developer, web programmer, IT service provider

2.1.3 Model solutions

- hermine [4] – **h**eritage-**e**xpedition, **r**ubble-**m**anagement & **i**ntuitive **n**ametag **e**xcavation (as no other alternative products known)

[4] https://github.com/JaegerIngenieure/hermine

2.2 Source research

2.2.1 Requirements

- Search for eyewitness reports, drawings, pictures, analogue and digital photos, newspaper articles, videos, 3D models, scatter plot, satellite images

2.2.2 Required personnel

- Archivist, (art) historian

2.2.3 Model solutions

- Recording of numerous documents mentioned above in private homes, social networks, online picture archives, picture search machines, public archives, libraries, internet forums, responsible authorities

2.3 Site inspection and survey

2.3.1 Requirements

- Precise on-site recording of position to enable implementation of other planning stages

2.3.2 Required personnel

- Architect, surveyor (engineer), drone pilot

2.3.3 Model solution

- Utilisation of digital cameras, measuring tools and equipment, laser scanners, drone photography, current satellite images

2.4 Creation of a 3D model

2.4.1 Requirements

- Creation of a model which is as accurate as possible of the condition of the building before the destruction
- Model storage in a data format, which can be used by a large number of programs (obj, stl, ply, ifc)

2.4.2 Required personnel

- 3D designer, 3D artist

2.4.3 Model solutions

Process	**Program**
Processing of all pictures found with the aid of photogrammetry into a scatter plot and then a 3D model	VisualSfM Regard3D COLMAP RealityCapture Agisoft PhotoScan
Deriving the 3D models from the scatter plot of existing laser scans	CloudCompare Faro Scene PointCab Leica Cyclone
Hand modelling based on the findings of the source search	Blender SketchUp

2.5 Geodetic measuring

2.5.1 Requirements

- Record the fixed points outside of the debris field in order to transfer the local in a superordinate (city, national, global) coordinate system

2.5.2 Required personnel

- Surveyor (engineer)

2.5.3 Model solution

- Use of tachymeter and/or GPS

2.6 Application of a grid

2.6.1 Requirements

- Designation of the find location of debris parts
- Coordination of work
- Adaptation of the scaling to the size of the debris mound and the debris parts

2.6.2 Required personnel

- Experienced project manager (architect or engineer)

2.6.3 Model solutions

- Designation and depiction with highly contrasting cordoning tape
- Precision must be verified by means of a digital grid on the PC
- Entry of the find location in the database

3 Documentation and recovery

3.1 Designation of the finds

3.1.1 Requirements

- Durability, mechanical loading, human readability

3.1.2 Required personnel

- Trained auxiliary staff

3.1.3 Model solution

- Pre-embossed brass plaques – sequentially numbered with unique numbers/ID
- Mounting by means of plugs and screws
- Entry of ID in the database

3.2 Recording of the finds of the uppermost find level

3.2.1 Requirements

- Documentation of the position of the debris field itself and to each other in order to ensure tracking of the find layer at a later date
- Scatter plots comparable with each other or 3D models
- Identification of individual finds

3.2.2 Required personnel

- Trained auxiliary staff

3.2.3 Model solution

- Small-scale debris fields – terrestrial laser scanner
- Extensive debris fields – drone photos and photogrammetry

3.3 Recover of the finds and uncovering of the next layer of finds

3.3.1 Requirements

- Careful and damage-free handling
- Handling corresponding to the debris part (size, weight, significance)
- No influencing of the find situation of other debris parts

3.3.2 Required personnel

- Trained auxiliary staff capable of driving fork lift trucks/excavators/crane

3.3.3 Model solution

- Depending on size, by hand, with excavator, manipulative grab, fork lift truck, revolving tower crane
- Removal of dust and rubble by means of industrial vacuums

3.4 Continuation of find description in interim storage

3.4.1 Requirements

- Recording of all specific features of the find (shape, colour, material, damage)

3.4.2 Required personnel

- Architect, archaeologist, trained workers

3.4.3 Model solutions

- Entry of all features in the database

3.5 Recording of the find surface

3.5.1 Requirements

- Recording of the find surface in a correspondingly sufficient resolution (depending on size, significance)

3.5.2 Required personnel

- Trained auxiliary staff

3.5.3 Model solution

- Use of hand scanner– DotProduct-Handscanner, Faro, Leica
- High resolution pictures/photogrammetry

4 Storage and archiving

4.1 Storage of finds

4.1.1 Requirements

- Conception of the storage surface corresponding to the expected finds
- Clear numbering of the storage locations

4.1.2 Required personnel

- Trained auxiliary staff

4.1.3 Model solutions

- Creation of different storage locations for corresponding sizes
- Spanning of a storage matrix
- Entry in database

4.2 Storage of broken parts

4.2.1 Requirements

- Classification as non-usable find
- Correct disposal of the remaining material

4.2.2 Required personnel

- Trained auxiliary staff

4.2.3 Model solution

- Sorting according to material

4.3 Find mapping

4.3.1 Requirements

- Assignment of as many finds as possible to the original location in the building
- Location of exact situation of find *or*
- Assigning to similar components *or*
- Use of the find in another location after processing

4.3.2 Required personnel

- Architect, archaeologist, engineer

4.3.3 Model solution

- Assignment via analysis of how the structure collapsed
- Assignment by means of geometry
- Assignment by means of material and colour
- Assignment by specific features
- Entry in the database

5 Analysis and evaluation

5.1 Creation of find designation

5.1.1 Requirements

- Choice of a scale suitable for the find
- Utilisation of created surface models
- Dimensioning in the plan
- Entry of damage

5.1.2 Required personnel

- Architect, technical drawer, trained auxiliary staff

5.1.3 Model solutions

- Alignment of the find 3D model on a cartesian coordinate system in suitable software
- Marking of areas of damage
- Creation of orthographic views of all relevant surfaces – however, at least left-right, front-rear, top-underside; if required cross section and isometric
- Arrangement and dimensioning of views, sections and isometries in the plan
- Example software: Trimble SketchUp→Trimble Layout→pdf/dwg
  Blender→CAD-Software→pdf/dwg

5.2 Reconstruction planning

5.2.1 Requirements

- Insertion of assigned finds in the 3D model
- Assignment by means of suitable colour scheme

5.2.2 Required personnel

- Architect, engineer

5.2.3 Model solutions

- Blue – finds that can merely find use as template stones
- Red – reusable finds that according to their origin in the facade can be unambiguously determined
- Green – reusable finds that are assigned unambiguously to the depicted facade area and a similar component
- All non-coloured stones need to be manufactured afresh as they are either incapable of being assigned or the degree of damage is too great.