Methodology for Collecting and Processing Data to Diagnose the Technical Condition of a Building: A Case Study of the State Tax University in Irpin (Ukraine)

Methodik zur Erfassung und Verarbeitung von Daten zur Diagnose des technischen Zustands eines Gebäudes: Eine Fallstudie der Staatlichen Universität für Finanzen in Irpin (Ukraine)

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The study focuses on assessing the damage to the main building of the State Tax University in Irpin (Ukraine), which was heavily damaged during the Russian occupation in 2022. The building was subjected to artillery shelling, blast waves, and direct shell hits, which caused significant damage to load-bearing structures, ceilings, and walls. In this regard, there was a need to conduct a comprehensive analysis of the building's condition to determine the extent of the damage and develop further restoration measures. The proposed methodology is based on the use of modern technologies, including terrestrial laser scanning, digital photogrammetry, UAV aerial surveys, and GNSS measurements. The combination of these methods allows for obtaining a detailed 3D model of the building. The obtained data allow not only for a qualitative assessment of load-bearing structures deformation but also for the identification of defects that may impact the building's operational safety. Considerable attention is paid to the analysis of deformations and collapse of floors, displacement of load-bearing walls, and deformations of the roof frame. To estimate these parameters, transverse and longitudinal cross-sections of the 3D model were used, which made it possible to identify critical areas of the building. In particular, the study revealed significant changes in the geometry of structural elements, indicating a possible loss of their strength. Particular attention is paid to the benefits of a combined approach that integrates traditional engineering methods with modern digital technologies. This approach ensures high accuracy in damage documentation and lays the foundation for further reconstruction planning. The use of laser scanning, digital photogrammetry, and UAVs significantly reduced data collection time and allowed for obtaining data about the building in hard-to-reach places. The results confirm the effectiveness and reliability of the proposed methodology, demonstrating its high accuracy and reliability for rapid assessment of the condition of buildings after damage. The proposed approach can be used not only to analyze the damage to individual buildings but also for comprehensive monitoring of the condition of urban development in the context of military conflicts.

Keywords: Terrestrial laser scanning, digital photogrammetry, aerial survey from UAV, technical condition of buildings, damage assessment

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Diese Studie befasst sich mit der Bewertung der Schäden am Hauptgebäude der Staatlichen Finanzuniversität in Irpin (Ukraine), das während der russischen Besatzung im Jahr 2022 stark beschädigt wurde. Das Gebäude war Artilleriebeschuss, Explosionsdruckwellen und direkten Treffern ausgesetzt, was erhebliche Schäden an tragenden Konstruktionen, Geschossdecken und Wänden verursachte. Vor diesem Hintergrund war eine umfassende Analyse des Gebäudezustands erforderlich, um das Ausmaß der Schäden zu bestimmen und geeignete Maßnahmen für die Wiederherstellung zu entwickeln. Die vorgeschlagene Methodik basiert auf dem Einsatz moderner Technologien, wie terrestrischem Laserscanning, digitaler Photogrammetrie, UAV-Luftbildaufnahmen und GNSS-Messungen. Die Kombination dieser Verfahren ermöglicht die Erstellung eines detaillierten dreidimensionalen Modells des Gebäudes. Die gewonnenen Daten erlauben nicht nur eine qualitative Bewertung der Deformationen tragender Strukturen, sondern auch die Identifikation von Defekten, welche die Betriebssicherheit des Gebäudes beeinträchtigen könnten. Besondere Aufmerksamkeit gilt der Analyse von Verformungen und Einstürzen von Geschossdecken, der Verschiebung tragender Wände sowie der Deformation des Dachtragwerks. Zur Ermittlung dieser Parameter wurden Quer- und Längsschnitte des 3D-Modells verwendet, wodurch strukturell kritische Bereiche des Gebäudes identifiziert werden konnten. Die Untersuchung zeigte insbesondere signifikante Veränderungen in der Geometrie der Konstruktionselemente, was auf einen möglichen Verlust ihrer Tragfähigkeit hindeutet. Hervorgehoben werden die Vorteile eines kombinierten Ansatzes, der klassische ingenieurtechnische Verfahren mit modernen digitalen Technologien verbindet. Dieser Ansatz gewährleistet eine hohe Genauigkeit bei der Schadensdokumentation und bildet die Grundlage für die weitere Wiederaufbauplanung. Der Einsatz von Laserscanning, Photogrammetrie und UAV verkürzte die Dauer der Datenerfassung erheblich und ermöglichte die Untersuchung auch schwer zugänglicher Gebäudebereiche. Die Ergebnisse bestätigen die Wirksamkeit und Zuverlässigkeit der vorgeschlagenen Methodik und zeigen deren hohe Präzision für die schnelle Bewertung des baulichen Zustands nach Schäden. Der Ansatz eignet sich nicht nur zur Analyse einzelner Gebäude, sondern auch für ein umfassendes Monitoring der städtischen Infrastruktur im Kontext militärischer Konflikte.

Schlüsselwörter: *Terrestrisches Laserscanning, digitale Photogrammetrie, UAV-Luftbildaufnahmen, Zustandsanalyse, Schadensbewertung*

1 INTRODUCTION

The State Tax University, established in 1921, boasts a rich and distinguished history. The University is a prominent educational and scientific symbol of the Hero City of Irpin, Ukraine. With over a century of academic excellence, it is the only higher education institution in Ukraine subordinated to the Ministry of Finance, specializing in the training of professionals in the field of public finance. The State Tax University is the alma mater of approximately 5 000 students, 314 academic and research staff members, and nearly 200 postgraduate students. Over its existence, the University has educated more than 80 000 professionals who have become part of Ukraine's intellectual, political, and business elite.

The history of the University's main academic building dates back to 1949, when construction began on a new facility designed to accommodate 525 students. Students actively participated in excavation and construction work, building not merely a structure, but a vision of the future. In December 1951, the main building was officially commissioned. From 2000 to 2002, the University undertook a large-scale renovation and expansion of the central building. The modernization brought state-of-the-art facilities and contemporary architecture, transforming the building into a European-level educational center.

On February 24, 2022, this history came to a standstill. During the period of active hostilities and subsequent occupation of Irpin (which lasted until March 28, 2022), the University suffered severe damage and destruction. Within a single day, nearly 80 shells and mines landed on the campus and surrounding areas. The University was deliberately targeted by tank fire, armored vehicles, and artillery of various calibers. On February 28, tank shells first struck University buildings. On March 3, the central building and the sports hall – where students, faculty, and local residents were sheltering – were shelled with mortars. One mortar landed just 20 meters from the shelter. These were deliberate attacks on civilians; no military personnel were present on University grounds.

The most extensive destruction occurred on March 24, shortly before the withdrawal of enemy forces. The central academic building, which housed the Rectorate, Accounting Department, Human Resources Office, Meeting Hall for official delegations, International Relations Department, Project Office, Document Management Division, the Student Government Hub, server rooms, six academic laboratories, and the Research Institute for Fiscal Policy, was completely destroyed. Significant damage was also inflicted upon the

University's assembly hall, classrooms, dormitories, sports complex, medical center, and administrative buildings.

Despite the ongoing war, the University continues to provide educational services. Quality education, domestic science, and the high intellectual potential of Ukrainian youth are essential for building a strong, modern European state. Therefore, the University administration is actively pursuing options for the reconstruction of the destroyed central academic building.

The State Tax University, like many other historical and cultural sites, is an important part of the country's architectural heritage. Therefore, active efforts are underway to plan the restoration of the damaged buildings, including the main building. Hence, the purpose of this study is to collect initial data for planning the restoration and analyzing the damage to the main building of the State Tax University using a set of modern geodetic methods.

2 METHOD

To achieve this goal, the paper proposes a methodology that combines various information-gathering methods with a modern algorithm for processing this data (*Fig. 1*).

The selection of data collection methods was based on a detailed analysis of their advantages and disadvantages when applied to similar facilities /Danesh & Rajabi 2022/.

The primary method for collecting metric information is terrestrial laser scanning. Numerous successful cases demonstrate the effectiveness of this method in assessing building damage, such as the aftermath of the fire at St. Nicholas Church in Kyiv in 2021 /Babak 2024/ and the Notre-Dame Cathedral fire in 2019 /Vallée et al. 2021/. Additionally, terrestrial laser scanning has been used for documenting war crimes /Svoboda & Mykhalchuk 2023/, /Matios 2024/ and for preserving cultural heritage post-war /Ivanova & Pestretsova 2022/, /Rogozha 2023/, /Savchyn et al. 2023/. Beyond its traditional use in damage assessment, terrestrial laser scanning is actively employed in the creation of BIM models of historical buildings /Barazzetti et al. 2015/, /Savchyn & Repechovych 2024/ and for their diagnostics and deformation monitoring /Nowak et al. 2020/, /Savchyn et al. 2025/. Recent studies indicate that the integration of terrestrial laser scanning with digital photogrammetry and BIM modeling significantly enhances the efficiency of cultural heritage documentation and preservation /Sampaio et al. 2021/, /Argasiński & Kuroczyński 2023/, /Borkowski & Kubrat 2024/.

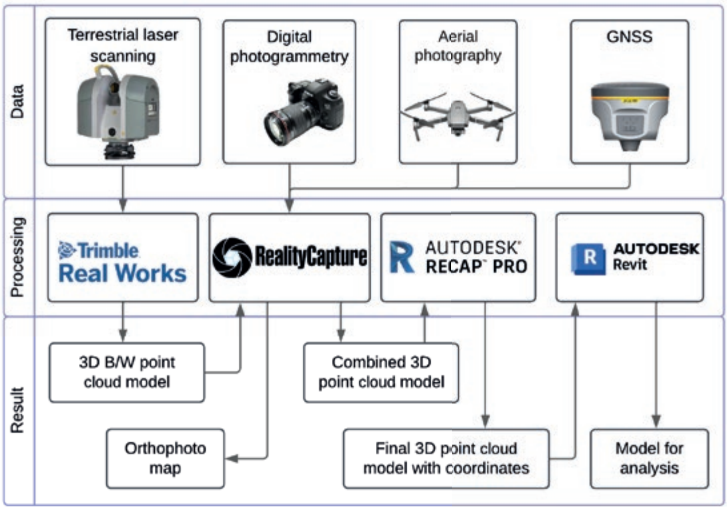


Fig. 1 | Research methodology

Digital photogrammetry was selected as the primary method for collecting color information /Dorozhynsky 2005/. /Hlotov 2008/ examines technologies used to create frontal projections of architectural structures through ground digital imaging. /Luhmann et al. 2023/ and /Rezvushkin 2019/ explore the principles, methods, and practical applications of digital photogrammetry. Meanwhile, /Kingsland 2020/ analyzes various software solutions for processing digital photogrammetry to assess their effectiveness in documenting and preserving cultural heritage sites.

Aerial photography using UAVs is employed to obtain data on the condition of hard-to-reach parts of the structure and to enhance the colorization of the model. Positive examples of this method's application are presented, among others, in /Chiabrando et al. 2017/ for assessing damage after the earthquake in Torino, Italy; /Lobanov et al. 2023/ for the remote assessment of damage to engineering and steel structures; /Petry & Becker 2022/ for data collection of damages after the flood disaster in the Ahr Valley, Germany, and in /Voloshyn et al. 2021/ and in /Voitenko 2009/ for monitoring and detecting deformations in buildings and engineering structures. /Chizhova et al. 2019/ demonstrated the combination of terrestrial laser scanning, UAV and close-range photogrammetry, and GNSS-based geo-referencing for 3D reconstruction of historical churches in Tbilisi, Georgia.

GNSS measurements are utilized to precisely georeference images and scale the model. /Uhl et al. 2024/ describe the application of GNSS for accurate positioning in 3D architectural projects, while /Levenchuk 2024/ examines the integration of aerial photography methods with GNSS measurements for the creation of orthophoto maps.

The study involved the use of various software solutions that enabled the integration of data obtained through different methods for filtering, visualization, and analysis.

3 RESULTS

Using the proposed methodology, representatives of the Institute of Geodesy at Lviv Polytechnic National University (Ukraine) conducted a series of works to document the damage to the main building of the State Tax University on October 22–24, 2024.

To collect metric data, two Trimble TX6 terrestrial laser scanners were used to scan the main damaged buildings of the State Tax University. The Trimble TX6 provides a scanning accuracy of ±2 mm at distances of up to 120 meters, with a scanning speed of up to 500 000 points per second. Scanning of the facade, interior, and basement areas was completed over two days, resulting in the establishment of 167 scanning stations.

Digital imaging was carried out using a Canon EOS 5D Mark III camera with a resolution of 22.3 megapixels and a Canon EF 50 mm f/1.8 lens. A total of 146 photos of the facade and 424 photos of the interior were captured.

The aerial survey was conducted using a DJI Mavic 2 Pro unmanned aerial vehicle equipped with a 1-inch CMOS camera (20 megapixels, f/2.8–f/11). The survey was performed from two altitudes at 60 and 80 meters. As a result, 452 images were captured.

To integrate and comprehensively process the results of terrestrial laser scanning, digital photogrammetry, and aerial surveys, reference marks and spheres were used. The spheres were employed for internal control, meaning their coordinates did not need to be determined. Meanwhile, GNSS measurements in RTK mode – using the South Galaxy G1 Plus GNSS receiver (horizontal accuracy: 8 mm + 1 mm/km, vertical accuracy: 15 mm + 1 mm/km) – were used to determine the coordinates of 30 reference marks. The resulting reference mark coordinates were determined with an average RMS error of ±12 mm horizontally and ±23 mm vertically.

Trimble RealWorks software was used to register (align) the scanning results from different stations. Registration was performed automatically, followed by a detailed analysis and manual adjustments to improve accuracy. After alignment in Trimble RealWorks, the registration accuracy was within 1.6–2.3 mm, the scan overlap ranged from 41 % to 88 %, and the confidence level was between 86 % and 98 %.

After successful alignment, the point cloud was exported for further processing in .e57 format, with reduced point density (to 2 mm × 2 mm) while preserving essential elements. Using Autodesk ReCap software, noise was filtered and removed, resulting in a cleaned point cloud. This stage was the most time-consuming compared to the others.

RealityCapture software was used to process the results of the aerial survey and digital photogrammetry. The processing was conducted separately for each image dataset. Control points identified in the images were used to align the 3D point model with the coordinate system. The residual absolute error for control points was 2.8 cm for aerial survey and 1.4 cm for digital photogrammetry. This error characterises the accuracy of the object's georeferencing.

As a result, three separate point clouds were generated: one from terrestrial laser scanning, one from aerial survey data, and one from digital photogrammetry. These point clouds were subsequently merged in RealityCapture, where the terrestrial laser scanning point cloud served as the reference dataset for alignment, producing a detailed, colorized 3D point model of the main building of the State Tax University (*Fig. 2*) and an orthophoto map of the university territory (*Fig. 3*).

Due to its higher precision and lower noise level, the terrestrial laser scanning point cloud was used to define the internal reference frame of the final 3D point model. The aerial survey and digital photogrammetry data were aligned to the terrestrial laser scanning dataset using signalised control points and common geometric features. The resulting residuals therefore characterise the quality of alignment in the global coordinate system and do not affect the relative accuracy of local geometric measurements performed within the terrestrial laser scanning reference frame. Therefore, the final colorized 3D point model achieved an absolute accuracy of approximately 2–3 cm in the global coordinate system (with a relative accuracy of 2–3 mm), while the orthophoto map was generated with a ground sampling distance of 2.3 cm/pixel.

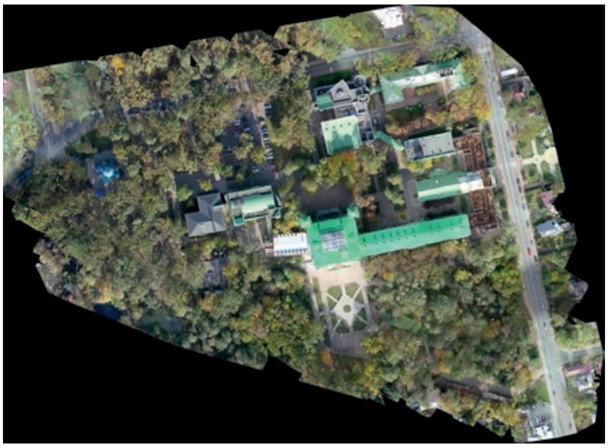


Fig. 3 | Orthophoto map of the university territory

It should be noted that relative accuracy measures the internal consistency of the terrestrial laser scanning point cloud, while absolute accuracy shows how well the 3D point model fits the global coordinate system. Relative accuracy depends on scanner noise and registration; absolute accuracy depends on GNSS and aerial/photogrammetry alignment.

The wall thickness was estimated directly from the 3D point model, without relying on fitted planes or simplified geometric shapes. Thickness was measured as the distance between interior and exterior wall surfaces, primarily captured by terrestrial laser scanning. Since both surfaces were measured within the same reference frame and have a relative accuracy of about 2–3 mm, the uncertainty of the thickness estimation was calculated using standard variance propagation, resulting in an accuracy of approximately 5 mm.

The final colorized 3D point model comprises over 1.1 billion points with a point density of 2 mm × 2 mm and was exported in .las format with a total file size of 96.5 GB. The entire data acquisition and processing workflow required approximately 120 person-hours, including 48 hours of fieldwork and 72 hours of data processing and verification.

a) Exterior view b) Top view c) Interior view

Fig. 2 | A detailed, colorized 3D point model of the main building of the State Tax University has been created

4 ANALYSIS

Large-scale destruction caused by shelling and the aftermath of the fire has been identified. Significant damage to window openings, the complete absence of the roof, and destruction of decorative elements and cladding were recorded. The facade has numerous cracks and significant burn marks. The upper floors suffered the most extensive damage, where ceilings and supporting structures partially collapsed, leading to deformation of the roof frame and partial roof collapse.

Using Autodesk Revit software, an analysis of the generated 3D point model of the main building of the State Tax University was conducted. A full 3D modelling of the building was intentionally avoided, since such a process inevitably leads to smoothing of the actual deformations and requires substantial time resources, which is impractical for severely damaged structures /Savchyn et al. 2023/. Instead, all measurements and technical assessment procedures were carried out directly on the 3D point model, which preserves maximum geometric detail and therefore most accurately reflects the real condition of the observed damage and deformations, ensuring objectivity and reliability of the engineering conclusions. According to the authors' estimates, and taking into account both the accuracy of the applied equipment and the generated 3D point model, the accuracy of deformation detection can be assessed at the level of approximately 5 mm (similar to wall thickness accuracy), which is sufficient for this type of investigation and enables reliable evaluation of structural displacements.

The analysis was performed along three longitudinal and three transverse sections of the building, constructed based on the 3D point model. The scheme of the constructed sections is shown in *Fig. 4*.

The advantages of this approach include the high accuracy and level of detail of the model, allowing for the recreation of the building with minimal errors – critical for assessing its technical condition. The ability to generate longitudinal and transverse sections in Autodesk Revit enables the visualization of damage and the identification of critical structural areas for further deformation assessment. Moreover, this approach significantly enhances the efficiency of repair planning by helping to pinpoint critical areas, optimize resource allocation for reconstruction, and make informed decisions regarding the building's further operation or potential demolition.

Fig. 5 illustrates the constructed cross-sections of the building, which facilitated the assessment of the condition of load-bearing structures such as walls, floors, and columns at various levels, as well as the metal roof frame.

Analyzing transverse sections 1–1' (see *Fig. 5a*), it can be observed that at level L1, the floor was filled in and covered with debris remnants resulting from the fire. At levels L2 and L3, the floors are completely absent, as the wooden structures that originally formed them were entirely destroyed by the fire. At levels L4 and L5, significant deformation of the metal beams, which served as the ceiling, was detected. Along the A-axis, the deformation reaches up to 240 mm at level L4 and up to 250 mm at level L5. Along the C-axis, the deformation reaches up to 150 mm at level L4 and up to 260 mm at level L5. Between levels L5 and L6, deformation of the metal roof frame and the collapse of the roof slab were recorded.

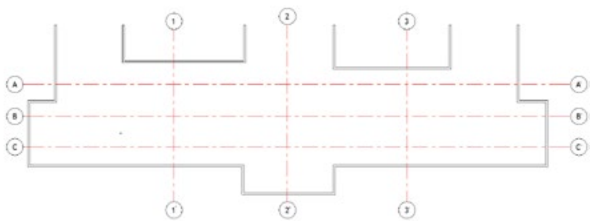


Fig. 4 | Scheme of the constructed sections (A, B and C: longitudinal sections; 1, 2 and 3: transverse sections)

Analyzing cross-section 2–2' (see *Fig. 5b*), which was constructed in the central part of the university's main building, it can be noted that no damage was found at levels L1 and L2, as the floor structures at these levels are made of reinforced concrete, ensuring their resistance to high temperatures. Between levels L4 and L6, ceiling deformation was recorded, specifically the deflection of metal beams, which reaches up to 200 mm between levels L4 and L5 and up to 270 mm between levels L5 and L6, as well as partial deformation of the roof frame.

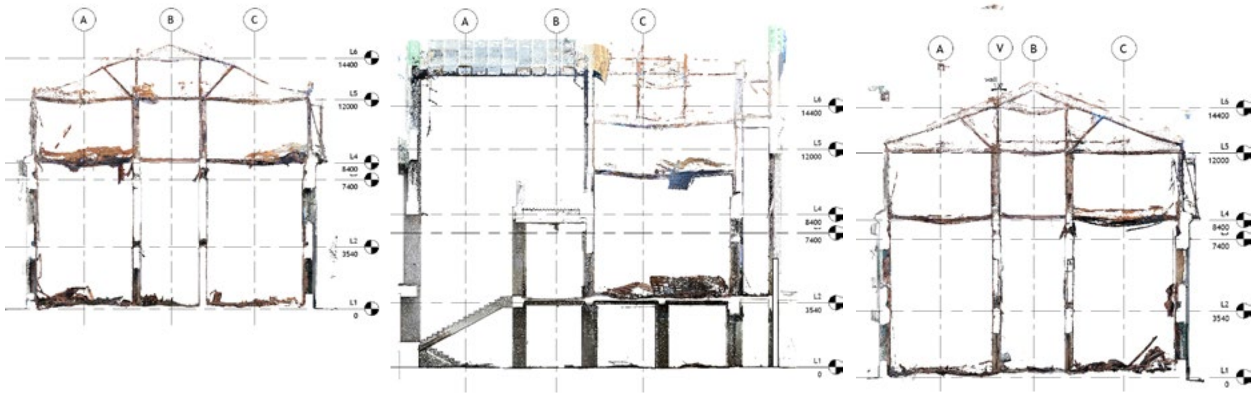
Analyzing cross-section 3–3' (see *Fig. 5c*), it can be observed that the main damage corresponds to that identified in cross-section 1–1' (see *Fig. 5a*). However, in addition, a tilt of the load-bearing wall between the A–A' and B–B' axes was detected. The 1° inclination of the wall towards the A-axis (equivalent to 122 mm at level L6) is likely caused by the collapse of the floor between the first and second floors, posing a serious risk to the structural stability of the building.

Fig. 6 presents the constructed longitudinal sections of the building, which enabled the assessment of its overall geometry, the identification of deflections and tilts of the supporting structures, and the evaluation of the condition of the interfloor slabs and roof frame.

Analyzing longitudinal section, A–A' (see *Fig. 6a*), significant damage is observed between levels L4 and L6. In particular, there is substantial deformation of the metal floor beams at level L4, with beam deflections reaching up to 250 mm, and at level L5, deflections reach up to 270 mm. Additionally, at level L4, a substantial quantity of metal roof slab remnants is present, along with roof frame deformation of up to 240 mm, which was likely caused by high temperatures during the fire. At levels L2 and L3, the floors were completely destroyed due to their wooden construction. However, in certain areas – to the left of axis 1–1' and to the right of axis 3–3' – the floors remained intact.

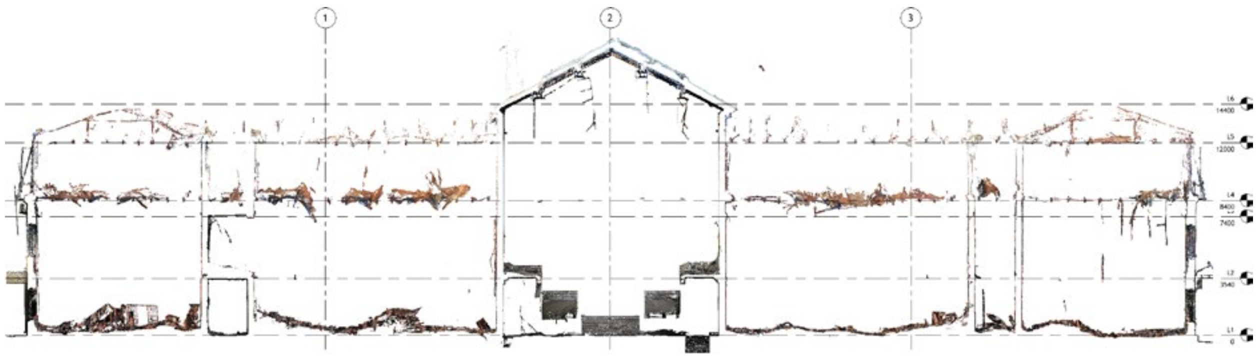
The analysis of longitudinal section B–B' (see *Fig. 6b*) confirms the complete destruction of the floor between levels L2 and L3. At the same time, deformation of metal beams was recorded at levels L4 and L5, with deflections reaching up to 120 mm. However, the stairwells located to the left of axis 1–1' and to the right of axis 3–3' remain undamaged, clearly indicating that the floor levels at L2 and L4 are still intact.

Analyzing longitudinal section C–C' (see *Fig. 6c*), deformation of the metal floor beams at level L4 was identified, with beam deflections reaching up to 360 mm on axis 3 and up to 240 mm on axis 1. At level L5, deflections reach up to 250 mm, and the damage to the roofing metal frame corresponds to that observed in section A–A'. No damage was detected on axis 2 between levels L1 and L2, as the floors and columns in this section are made of reinforced concrete. Additionally, both stairwells on the left and right sides remain undamaged.

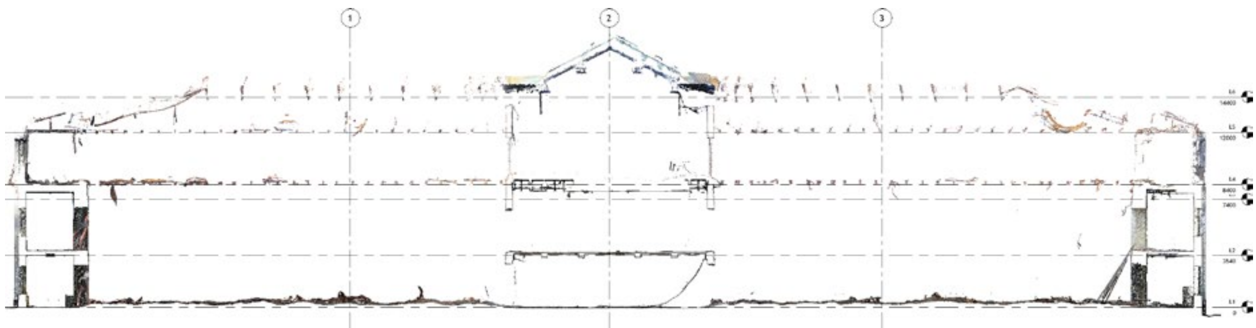


a) Transverse sections 1 – 1' b) Transverse sections 2 – 2' c) Transverse sections 3 – 3'

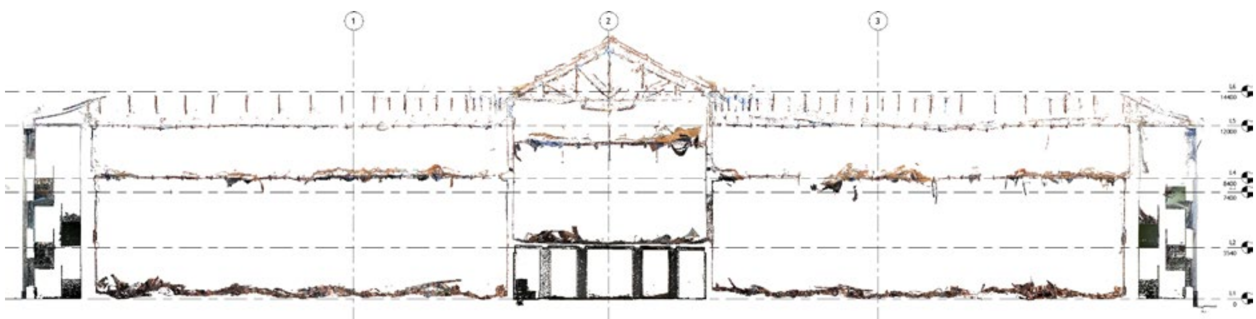
Fig. 5 | Constructed transverse sections



a) Longitudinal sections A – A'

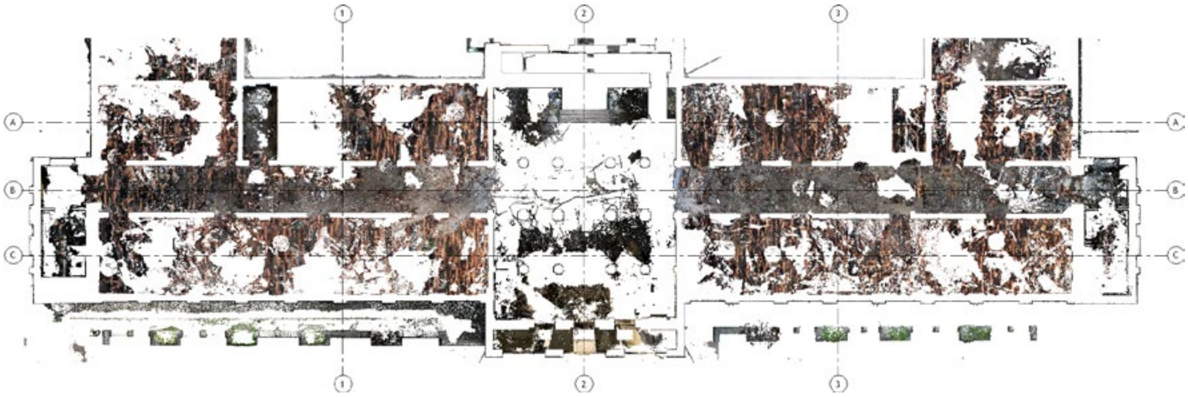


b) Longitudinal sections B – B'

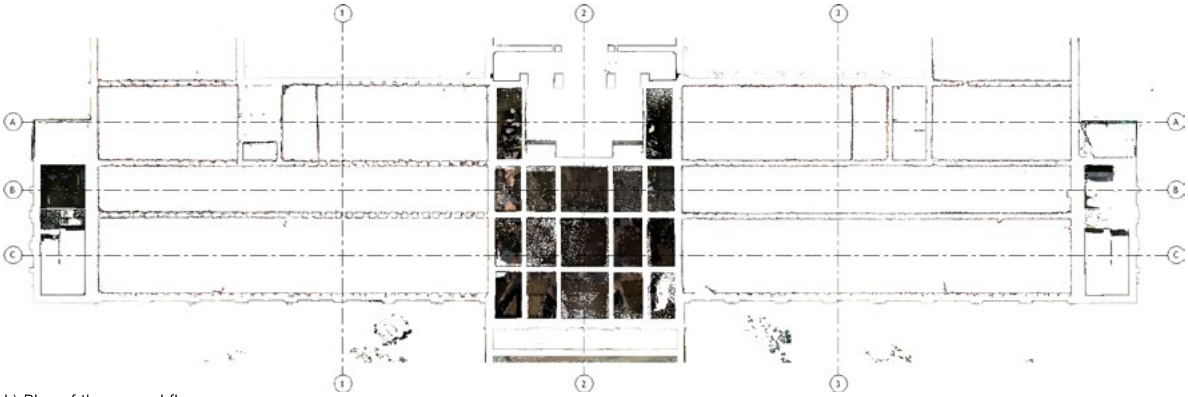


c) Longitudinal sections C – C'

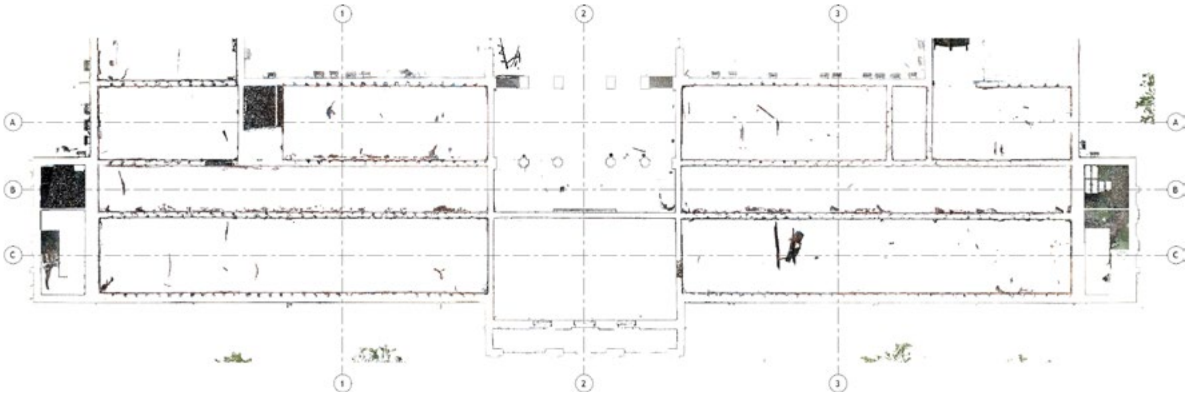
Fig. 6 | Constructed longitudinal sections



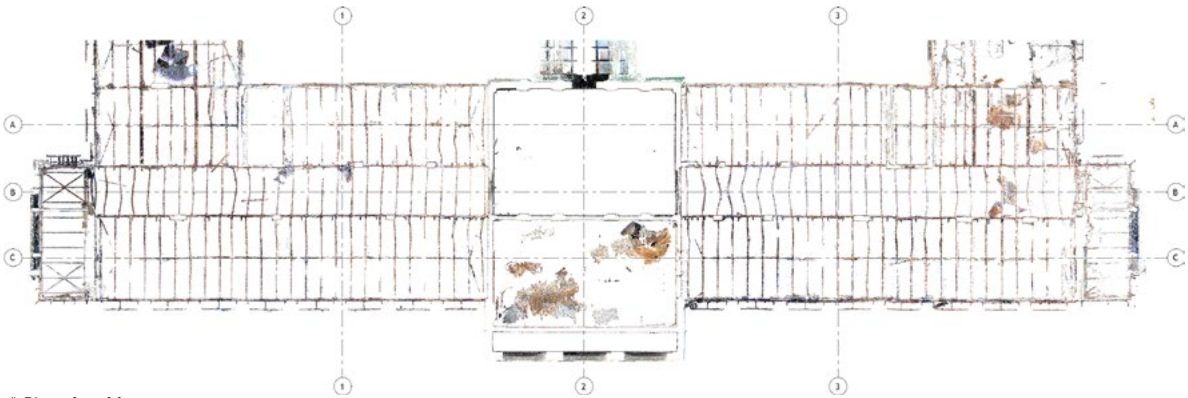
a) Ground floor plan



b) Plan of the second floor



c) Plan of the third floor



d) Plan of roof frame

Fig. 7 | Floor plan

Analyzing the floor plans at levels L1, L2, L3, and L5 (see *Fig. 7*), several structural characteristics and damage patterns can be identified:

The ground floor plan of Level L1 (see *Fig. 7a*) shows partial infill with post-fire debris, primarily on the left and right sides of the building, corresponding to areas affected by the collapse of the upper structures. The floor structure at this level, predominantly made of reinforced concrete, remained largely intact due to its high fire resistance. However, damage to the wall along the B-axis was observed, resulting from the collapse of the ceiling.

At Level L2 (see *Fig. 7b*), the floor structure sustained significant damage, particularly along the A, B, and C axes. Originally constructed using wooden beams, the floor system was completely destroyed in several locations due to high temperatures and combustion of the wooden elements. At the stairwells (located at the ends of axes 1 and 5), the concrete platforms remained intact.

5 DISCUSSION

The study demonstrates the high effectiveness of modern technologies in assessing the technical condition of the building; however, certain aspects require critical analysis. The integration of terrestrial laser scanning, digital photogrammetry, and aerial surveys enabled the creation of a detailed 3D point model of the structure. Nevertheless, potential errors may arise when stitching (merging) these datasets into a single point cloud. The damage analysis of the building revealed critical structural issues, including: complete destruction of the ceilings on the 2nd and 3rd floors, deformation of metal beams ranging from 100 mm to 360 mm, call inclination of 1°, deformation of the metal roof frame. Based on the collected data, it can be concluded that there is a high probability of further structural collapse in certain areas of the building. These elements cannot be restored and will require demolition.

Conducting three longitudinal and three transverse sections provides sufficient data for general analysis. However, for a more detailed assessment, additional sections would be beneficial. While expanding the number of sections could enhance the completeness of the analysis, it would also require more time and labor-intensive processing.

The results of this study were provided to the State Tax University for further integration into the development of a comprehensive 3D point model. This model will facilitate the creation of a high-fidelity virtual representation /Birillo 2014/, enabling the establishment of a digital archive /Bilov 2023/, /Neshchadym 2023/ for historical, scientific, and expert research. Additionally, it will serve as a visualization tool for architects and stakeholders, presenting the building in a clear and interactive format /Pidkuiko 2023/, /Hajirasouli & Banihashemi 2022/.

Furthermore, the collected data can be utilized to develop an augmented reality (AR) model /Bondar & Zhyteniova 2023/, which could support virtual tours /Khlopetskyi 2023/, /De Fino, Bruno & Fatiguso 2022/ or serve as a comparative visualization, illustrating the building's condition before and after destruction /Honcharenko et al. 2023/.

The data obtained became the basis for an architectural competition to create a project for the construction of a new main building of the university. This competition is a response to the devastating structural damage sustained during the Russian invasion, which rendered key parts of the university irreparable. The objective is to design a modern, inclusive, and sustainable educational space that reflects resilience and serves as a symbol of recovery for the Irpin community. The initiative aims not only to replace what was lost but to create a modern, inclusive, and sustainable space that will serve as a beacon of resilience and innovation.

Over 500 applications from 87 countries around the world were submitted by architectural firms and individual designers, who were tasked with creating a campus that seamlessly integrates with the city, supports veterans and students with physical disabilities, and meets high standards of sustainability and cost-efficiency. The competition emphasizes visionary design, with evaluation criteria including architectural form and function, equity strategies, sustainability, site integration, and economic feasibility. The jury consists of respected experts from international and local fields, including Sergii Marchenko, Minister of Finance Ukraine, Kasper Heiberg Frandsen, Design Principal at Schmidt Hammer Lassen Architects, Wendy Hillis, Assistant Vice Chancellor and Campus Architect, University of California, Berkeley, Antonina Kaplya, Architect and Founder, TSEH Architectural Group, Ivan Kipish, Chief Architect of Irpin, Vitalii Melnyk, Vice President, UDP, David Lenox, University Architect and Director of Campus Planning, Stanford University, Steve Wiesenthal, Campus Environments Principal and Architect, Studio Gang, Szymon Wojciechowski, CEO and Architect-Partner, APA Wojciechowski Architects.

Among the top 49 projects from 18 countries around the world, a winning design will be selected – one that integrates best practices in contemporary educational architecture, emphasizes accessibility for all, and incorporates local, energy-efficient materials and technologies. Ultimately, the project aspires to deliver more than not just a campus for students and faculty – it seeks to become a powerful symbol of renewal, growth, and unity for the Irpin community.

6 CONCLUSION

This study highlights the critical role of modern reality capture methods in assessing damaged architectural structures, ensuring the preservation of cultural heritage, and facilitating restoration planning. The research emphasizes the use of terrestrial laser scanning, digital photogrammetry, and aerial photography, which provide high-precision and detailed 3D point models. These models serve as the foundation for damage assessment and the development of restoration or reconstruction strategies.

A key achievement of this work is the creation of an integrated point cloud, combining data from terrestrial laser scanning, aerial photography, and digital photogrammetry. This comprehensive dataset captures all aspects of the building, including facades, interiors, and basements. Although the structure itself will not be restored, the generated models hold significant practical and scientific value. They offer essential data for historians, architects, and researchers, preserving a detailed record of the building's wartime condition and destruction.

Thus, the study's findings have long-term implications, even if the building is dismantled. The creation of 3D point models enable the digital preservation of cultural heritage, supports further research, and demonstrates the potential of modern technology in safeguarding Ukraine's architectural history. Additionally, the detailed damage analysis – particularly concerning floor and wall destruction – underscores the importance of precisely documenting structural changes for both scientific and engineering applications.

The conducted research provides grounds to consider the necessity of implementing modern 3D scanning technologies in the reconstruction of Ukraine's infrastructure, which has suffered significant destruction and damage as a result of military actions. The use of such technologies offers a number of advantages, namely: the possibility of integration into BIM systems, archiving of the actual condition, rapid data capture, significant improvement in planning, and cost savings in future restoration efforts.

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