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Learning from the Past: Rediscovering Traditional Medieval Wood Tar Adhesives for Sustainable Stone Conservation and Built Heritage

Aprendiendo del Pasado: Redescubriendo los Adhesivos de Alquitrán de Madera Medievales Tradicionales para la Conservación Sostenible de la Piedra y el Patrimonio Construido

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ABSTRACT

This paper outlines a research project on the use of wood tar as adhesive for architectural stone repairs. Tar was identified as having been used in medieval repair techniques on Stavanger cathedral in Norway, as well as on several other medieval cathedrals in England and Germany. The hypothesis is that a complex adhesive mixture based on wood tar was manufactured and strategically employed by medieval artisans in northern Europe as stone repair material. Given that such repairs have withstood centuries of wear, there must have been extensive material knowledge and awareness of the complex requirements of structural adhesives. These historic tar repairs created the impetus for a research project, the aim of which is to rediscover the lost medieval art of traditional stone repair using wood tar adhesives, recreate the historic adhesive and repurpose it for modern conservation practice. By reintroducing traditional wood tar adhesives based on natural renewable source materials, we could potentially reduce dependence on synthetically manufactured adhesives. Thus, newly-discovered medieval techniques which have successfully lasted centuries will be drawn on to help solve the limited selection of suitable adhesives for stone conservation, contributing to future preservation of stone architecture and the built heritage environment.

Este artículo describe un proyecto de investigación sobre el uso de alquitrán de madera como adhesivo para reparaciones de piedra en patrimonio construido. Se identificó que el alquitrán se había utilizado en técnicas de reparación medievales en la catedral de Stavanger en Noruega, así como en varias otras catedrales medievales en Inglaterra y Alemania. La hipótesis es que los artesanos medievales del norte de Europa fabricaron y emplearon estratégicamente una mezcla adhesiva compleja a base de alquitrán de madera como material de reparación de piedra. Dado que tales reparaciones han resistido siglos de desgaste, debe haber habido un amplio conocimiento de los materiales y conciencia sobre los complejos requisitos de los adhesivos estructurales para este tipo de adhesivos. Estas reparaciones históricas de alquitrán crearon el impulso para un proyecto de investigación, cuyo objetivo es redescubrir el arte medieval perdido de la reparación tradicional de piedra utilizando adhesivos de alquitrán para madera, recrear el adhesivo histórico y reutilizarlo para la práctica de conservación moderna. Al reintroducir los adhesivos tradicionales de alquitrán de madera basados en materiales naturales renovables, podríamos reducir potencialmente la dependencia de los adhesivos fabricados sintéticamente. Por lo tanto, se aprovecharán las técnicas medievales recién re-descubiertas que han durado siglos con éxito para ayudar a resolver la limitada selección de adhesivos adecuados para la conservación de piedra, contribuyendo así a la preservación de la arquitectura de piedra y del patrimonio construido.

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A medieval stone adhesive case study with broad implications

Wood tars and tar-based adhesives have a very long history of use, and as the current publication demonstrates, novel uses of wood tar are still being identified. Simultaneously, even though adhesive research has been undertaken in various conservation disciplines, the use of adhesives in stone construction and architectural repair has received only limited attention. Within the course of a recent pilot study undertaken on Stavanger cathedral in Norway, extensive evidence of tar-based medieval repair adhesives was discovered (Ebert and Bjelland 2023). In this paper, the pilot study will be summarized, and latest results of the ongoing research presented, prior to addressing the repercussions and potential provided by this discovery.

Stavanger cathedral is a medieval stone cathedral located in south-western Norway. The cathedral

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remains in active religious use and has only been subjected to a limited degree of change since the Middle Ages. Consequently, Stavanger cathedral is Norway's most authentic medieval stone cathedral and is automatically protected under the Norwegian Cultural Heritage Act. The cathedral was constructed in the first quarter of the twelfth century using rubblestone masonry, with local soapstone employed for ashlar and decorative stone carvings. The original Romanesque nave remains from this early construction period. Around 1300, a Gothic construction period led to the cathedral's original choir being replaced, and two towers raised at either end of the new east façade (Figure 1). In preparation for the cathedral's and city's 900-year anniversary in 2025, a large ten-year restoration and conservation project is currently underway. Within the scope of this cathedral restoration project, the Museum of Archaeology at the University of Stavanger is responsible for conservation and documentation of the cathedral's soapstone exterior and interior, as well as the Renaissance inventory.

Pilot study and preliminary results

While undertaking condition assessment and documentation of Stavanger cathedral for the ongoing conservation project, the conservators discovered an unusual adhesive-like substance underneath some stone repairs (Figure 2). The adhesive was brownish black in appearance and had numerous inorganic inclusions, as observed using light microscopy. After initial examination, the nature and context of the find led to the hypothesis that the adhesive may be from historic tar repairs. Given the novelty of this discovery, a pilot study was undertaken to explore this initial hypothesis, and to determine the age of the repairs.

Figure 1. Stavanger cathedral, with Gothic east façade and towers prior to conservation. Image: Museum of Archaeology, University of Stavanger.

Samples of the adhesive were taken from a wide range of locations on the cathedral for further investigations. Four samples were selected for radiocarbon dating and material identification, these samples derived from both the interior and exterior of the cathedral to provide a broad cross-section of sites (see Table 1 for details). Gas chromatography – mass spectrometry (GC – MS) was employed for identification of the organic components in the adhesive. Radiocarbon dating is considered a suitable technique to date the wood tar repairs on Stavanger cathedral and link them to the respective building construction phases. The first set of radiocarbon dates obtained for tar repairs on Stavanger cathedral is reported in Table 1. This will be followed by radiocarbon dating additional tar repair samples from other locations on the cathedral, as well as other sites in Norway and from churches in other countries, as identified during the field surveys.

Material characterization studies undertaken on four of the samples from Stavanger cathedral during the pilot study identified pine resin, beeswax and inorganic fillers, in addition to pine tar (Table 1). The inorganic additives will be subjected to further study in order to determine whether they derive from stone debris or from other sources, and whether it is possible to determine the proportion of inorganic content. The radiocarbon dates of the four samples are in agreement, providing a *terminus post quem* for when the pine tar could have been manufactured and applied. These results clearly link the tar repairs to the Gothic construction period of Stavanger cathedral.

Results of the pilot study are revolutionary: an adhesive mixture based on pine wood tar with further additives was used as an adhesive for hundreds of large and small stone repairs dated to the cathedral's Gothic reconstruction period (see Ebert and Bjelland 2023 for further details). Surprisingly, the use of wood tar as a historic repair material on stone buildings is currently undocumented. This technique of stone repair has the potential for providing alternative

Figure 2. Stone repair with tar adhesive. Image: Museum of Archaeology, University of Stavanger.

Table 1. Four adhesive samples investigated using GC – MS and radiocarbon dating. All radiocarbon dates are reported to 95% probability (2σ, IntCal20).

Sample number and location on Stavanger cathedral	GC-MS results	Age range (cal AD)
#65 Choir interior, north wall (repair)	Pine tar, pine resin, beeswax	1027–1156
#121 Choir interior, ribbed vault	Pine tar, pine resin, beeswax	1035–1157
#139 Choir exterior, south facade window (repair)	Pine tar, pine resin, beeswax	1044–1213
#141 North tower (repair)	Pine tar, pine resin, beeswax	1052–1217

sustainable methods and materials for conservation based on traditional historic techniques.

The research project

The novel findings uncovered as part of the pilot study provided the impetus for the development of a larger research project, the aim of which is to investigate the historic and potential future use of wood tar adhesives in conservation. The project is called *Sticking Stones: rediscovering medieval wood tar adhesives for stone conservation*, and is funded by the Research Council of Norway, with co-funding and in-kind contributions by the project owners and respective partner institutions, contributing to a total budget of NOK 16 million (EUR 1.4 million). The project is scheduled to run for four years from 2024 to 2028 and consists of five work packages designed to address the research aims and project objectives. The interdisciplinary project is led and coordinated by the Museum of Archaeology at the University of Stavanger in Norway. Partner institutions in Norway include the Norwegian Institute for Cultural Heritage Research and the University of Bergen, while international collaborators are located at Delft University of Technology in the Netherlands and the Getty Conservation Institute in the USA. The project team consists of specialists from conservation, archaeology, art history, materials science, geology, and biology. A PhD candidate based at the Museum of Archaeology will join this interdisciplinary group. The project is supported by an advisory panel consisting of stakeholder representatives and experts from stone conservation, traditional masonry practitioners, materials characterization, and cultural heritage management. In addition, an innovation panel advises the principal investigator on intellectual property (IP) rights, IP management, market research, and product development.

The project team is undertaking pioneering research into the historic use of tar as stone adhesive, subsequently testing its potential application in architectural conservation. The project focuses on one case study, Stavanger cathedral, while also considering tar and other adhesive repairs in northern European countries including the United Kingdom and Germany. What follows is a brief review of the research history of wood tar and stone adhesives to demonstrate current knowledge gaps that are being addressed by this research.

Wood tar

Throughout history, wood tars have been prepared and employed by humankind as adhesives, sealants, and coatings. Wood tars are produced from the destructive distillation of biomass. Wood tar is a complex mixture of hundreds of hydrocarbon compounds, mainly a range of resin acids and phenols. In many parts of Scandinavia, the traditional funnel kiln distillation process involves kilns with a controlled burning system that creates a low-oxygen environment (Egenberg 2003; Hennius 2018). To produce pine wood tar, old pine stumps are used since these contain the highest amount of pine resin. The wood is chopped and dried, and once the kiln is constructed, a circular wood stack is made, which is then covered in turf and ignited, allowing it to smoulder over the course of many hours. The tar then runs off via the funnel into collecting containers.

There is significant archaeological evidence of Neanderthal production of birch bark tar in the Palaeolithic (Kozowyk, Baron, and Langejans 2023a; Kozowyk, Fajardo, and Langejans 2023b). Residue analysis has led to the identification of birch bark tar on flint tools as well as a decorative or waterproof coating and repair adhesive on ceramics (Junkmanns 2001; Morandi, Porta, and Ribechini 2018; Niekus et al. 2019). In Norway, birch bark tar is known to have been used as caulking resin or sealant for lath-walled wooden vessels during the Early Iron Age (Nordby 2009). Birch bark tar production in Scandinavia remained on a small scale, while pine tar production developed into larger-scale production processes during the Late Iron Age, particularly the Viking period (Hennius 2018; Hjulström, Isaksson, and Hennius 2006). Hennius concludes that Viking shipbuilding provided the impetus for pine tar production on an expanded scale (Hennius 2018). Pine tar was used as caulking material in shipbuilding (Figure 3), also in postmedieval and pre-industrial times (Loewen 2005). In this context, fibrous material was soaked in pine tar and wedged between planks to create a watertight seal.

Another important use for pine tar is as a surface coating for wood. Pine tar was, and still is, used extensively as a protective and sacrificial coating on wooden stave churches (Egenberg 2003), and on vernacular historic wooden buildings and shingle roofs throughout Scandinavia (Källbom 2015; Lindblad, Fredriksson, and Källbom 2021). In fact, pine tar was a significant Scandinavian export commodity in the early modern period. Despite this ubiquitous use in earlier centuries,

Figure 3. Medieval ceramic vessel containing wood tar, likely used in caulking. Marine archaeological discovery from the Karmsund strait in Rogaland county, south-western Norway. Image: Museum of Archaeology, University of Stavanger.

wood tar is not currently documented to have been employed for stone repair beyond the recent discovery on Stavanger cathedral. Nevertheless, initial research by the author has revealed archival evidence which could indicate that pine tar adhesives were regularly used for stone repair and construction in medieval times in northern Europe. This will be explored in greater detail as research progresses, as it is a topic that has hitherto not been studied.

Stone adhesives

Craft skills play a crucial role in stone conservation, and collaboration between conservators, stone carvers and masons is necessary for successful remedial stone conservation. Techniques employed in architectural stone conservation have changed minimally over the centuries, being based on traditional stonemasonry skills. Architectural stone is usually repaired through full or partial replacement of deteriorated stone, ensuring that the building maintains its structural integrity. A range of mortars and cements is used, occasionally in conjunction with adhesives and metal pins, to hold indents in place. The use of wood tar in stone repair is currently undocumented, while mortar and synthetic resins are commonly used in this context nowadays (Daniels 2015; English Heritage 2012). Adhesives that are employed in stone conservation are more commonly used on sculptures or monuments, particularly indoors, rather than in the built environment. Weather exposure is an extreme environmental stress for adhesives, limiting their successful outdoor use in the built heritage sector to only a few adhesives, with the most common being polyester or epoxy resins (English Heritage 2012). Historically, a range of adhesives has been employed for repair and gluing of stone, though there is as yet very limited research on the topic (Alsalim 1981; Griswold and Uricheck 1998; Jorjani et al. 2009). Documented historic adhesives used in stone conservation include, for example, shellac, wax, animal glue, and bitumen, as well as various mortars and cements.

Stone adhesives mentioned in medieval written sources include animal glues (Smith and Hawthorne 1974), while a medieval Italian recipe for a mixture of mastic and wax has been described (Thompson 1954). However, use of wood tar as a stone adhesive has so far only been tentatively identified in a few medieval English purchase records linked to cathedral construction. In these contexts, a repair adhesive consisting of wax, tar, rosin and/or pitch is mentioned, occasionally with the addition of stone or tile dust (Raines 1859; Salzman 1952). Thus, archival evidence appears to indicate that wood tar was used for stone repair in medieval England. It is possible that documented evidence of medieval adhesive repairs identified around fifty years ago provides the missing link here. During conservation work on several English cathedrals in the 1970s and 1980s, numerous medieval adhesive findings were registered, with evidence on Wells and Salisbury cathedrals, amongst other places (Ayers and Sampson 2000; Harris 1982; Sampson 1998). The description of these adhesive repairs is remarkably similar to the newly-discovered tar findings in Stavanger, though the composition of the English samples has not been confirmed by materials analysis and will have to be analysed and compared to the Norwegian material. Despite these adhesive findings having been documented many decades ago, knowledge of medieval adhesive repairs in northern European contexts has not progressed significantly in stone conservation or building archaeology since then.

Knowledge needs and research objectives

This brief overview of wood tars and stone adhesives highlights the fact that there are significant knowledge gaps in building archaeology, stone conservation and adhesives research. There is currently no in-depth study of traditional medieval adhesives used in stone repair. Knowledge of wood tar production and use is more comprehensive, though there are no studies of wood tar usage in the context of architectural stone. The discovery of hundreds of tar repairs on Stavanger cathedral, in combination with archival sources and other medieval adhesive repairs tentatively identified elsewhere in northern Europe, has the combined potential to shed light on an understudied historic craft. This unique discovery highlights a knowledge gap on historic approaches to conservation and practices of repair. Such underexplored findings may indicate widespread northern European use of tarry adhesives in medieval stone construction and repair, shedding light on a neglected resource with significant potential for contemporary applications.

As a result of these pressing knowledge needs, it was decided to develop the *Sticking Stones* project, the aim of which is to rediscover the lost medieval art of traditional stone repair using wood tar adhesives. This will involve recreating the historic adhesive mixture and repurposing it for modern conservation practice and the built environment. It is exemplary that historic tar repairs on Stavanger cathedral have withstood many centuries of adverse coastal Scandinavian climate extremes without adhesive failure. Such longevity gives wood tar as a stone adhesive the potential to be used in conservation as a replacement for synthetic resins. This presents a novel solution for conservation in the form of alternative adhesives based on forgotten historic techniques.

The primary objective of the research is the systematic survey of historic architectural stone adhesives, highlighting the medieval artisan's complex toolkit, craft skills and early awareness of conservation ethics. This feeds directly into the secondary objective of material characterization for the development of a new sustainable adhesive for stone conservation based on historic materials and techniques. As identified in the pilot study, the main hypothesis is that a complex adhesive mixture consisting of tar and other organic and inorganic additives was manufactured and strategically employed by medieval artisans as a stone conservation and repair material in northern Europe. Given that large stone blocks were successfully attached and have withstood centuries of wear (Figure 4), there must have been extensive material knowledge and awareness of the complex requirements of such adhesive mixtures. The project team will uncover the lost medieval tradition of tar repairs and use this new-gained knowledge of traditional materials and techniques in contributing to method development for modern stone conservation.

Figure 4. Medieval tar repair on Stavanger cathedral. Image: Museum of Archaeology, University of Stavanger.

Project methodology

Numerous complementary methods are being employed to achieve the project aims, covering archival research into historic adhesives, explorations of tacit knowledge and the intangible heritage of craft skills, material characterization, adhesive re-engineering, and performance testing. Historical instruction manuals and primary sources are being studied to examine historic adhesive technology. Site surveys of selected medieval churches and lapidaries in northern Europe are currently being undertaken, mapping the incidence of medieval tar repairs in the built environment by looking for physical evidence of wood tar. At present, Heilig-Kreuz-Münster in Schwäbisch Gmünd, Germany, as well as the lapidary of Trondheim Cathedral Restoration Workshop in Norway are being evaluated, with further site surveys planned. In addition, a community science project is being set up to engage local communities in participatory heritage research, allowing participants to document potential adhesive repairs on medieval architectural heritage. This contributes to a broader scope than possible purely through selected site surveys.

The detailed composition of historic tar repairs is currently unknown, yet successful survival for centuries is testament to complex adhesive formulation. This crucial knowledge gap required for subsequent adhesive replication is currently being addressed through comprehensive material characterization of the organic and inorganic components of historic samples (Figure 5). Successful adhesive formulations often consist of mixtures, using additives to modify their working properties.

Figure 5. One of the tar adhesive samples investigated during the project. Image: Museum of Archaeology, University of Stavanger.

Additional samples from Stavanger cathedral and other churches elsewhere are being subjected to detailed material characterization to obtain as complete a picture as possible, given the possibility of variability in application and composition. Results will be compared to reference samples and mixtures of reference samples of known proportions, to determine accurate ratios of components. Organic characterization is being undertaken through Fourier transform infrared spectroscopy and GC-MS. Sample cross-sections and thin sections (petrography for inorganic inclusions) are being examined with light microscopy and scanning electron microscopy for insight into additives in the adhesive mixture. Identification of the inorganic components involves scanning electron microscopy with energy-dispersive spectroscopy and Raman spectroscopy.

Compositional data derived from material characterization will be compared to historic archival recipes to replicate adhesive mixtures. The project researchers will subsequently evaluate adhesive performance and test its application for stone conservation. The astounding performance of 700-year-old tar repairs is testament to their potential, and while tar may not outperform modern synthetic resins in all capacities, it has the ability to be a suitable natural alternative, given the correct blend with additives.

Standardized industrial adhesive material tests will be used to quantify properties of the re-invented adhesive. This allows comparison with modern synthetic resin adhesives. Stone adhesives need to withstand a range of environmental conditions for successful indoor and outdoor use. Therefore, replicated adhesives will undergo accelerated hygrothermal ageing at elevated temperatures and cyclic relative humidity. Samples taken at three different ageing durations will be subject to tensile lap shear tests and rheological analysis and will be compared to modern synthetic resin adhesives. Lap shear tests will be conducted to measure the quasi-static shear strength of each adhesive on different stone adherends, including soapstone due to its ubiquitous use on Stavanger cathedral. Rheology testing will measure creep, viscosity, and dynamic moduli at a range of temperatures. Given the importance of moisture passage in stone buildings, moisture uptake and its effects on material properties will be tested by water immersion and measuring changes in weight and rheological properties. Following lab testing, the adhesive will be subjected to real-life performance and application testing by relevant stakeholder groups to explore practical tar adhesive usage.

Tacit knowledge and craft skills

An exploration of the fundamental interplay of craft skills and tacit knowledge in relation to architectural conservation has received limited academic attention so far. Project researchers are exploring how tacit knowledge and the intangible heritage of craft skills used in medieval tar repair can inform current conservation practice. Polanyi's theory of tacit knowledge acts as guiding principle in this approach. Tacit knowledge is embodied in the idea that 'we can know more than we can tell', implying that knowledge has informal dimensions based on intuition, experience, and skill (Polanyi 1966, 4). For conservators working on Stavanger cathedral, tacit knowledge was embodied in the intuitive connection between the untapped potential of newly discovered historic tar repairs in addressing a pressing problem faced in contemporary stone conservation, namely the absence of suitable adhesives for the conservation of soapstone beyond synthetic glues. This demonstrates that the pursuit of scientific discovery also relies on tacit knowledge, while simultaneously exploring the embodied knowledge of a lost medieval craft.

Historical adhesives and medieval tar repairs are being examined through the lens of tacit knowledge and the intangible cultural heritage of craft skills. Traditional craftsmanship is protected under the UNESCO Convention for the Safeguarding of Intangible Cultural Heritage, yet academic research on craft in cultural heritage is still somewhat limited (though see, for example, Almevik 2016; Westerlund, Groth, and Almevik 2022). The project explores how the development of a novel conservation adhesive is informed through the study and understanding of a historic craft. This guarantees continuity and relevance of traditional skills into the future through analytical discovery and reengineering for modern conservation. Craft as a complex interplay of tacit knowledge, experiential learning, intuition, experimentation and awareness of material technology and its implications is being investigated in the process. In this manner, lost historic craft knowledge can be re-learnt and brought to life for future traditions of practice.

Close reading of physical evidence provides insight into the mind of medieval artisans, demonstrating extensive material awareness and ethical consideration with parallels in modern conservation practice (Figure 6). The project outputs will expand the corpus of research into concepts of authenticity by demonstrating the role of processual authenticity in the built environment. By framing this study within perspectives of tacit knowledge, craft skills and processual authenticity, the research demonstrates how tangible and intangible heritages are intimately combined within conservation. The discipline of conservation, while often seen to focus on material traces of the past by preserving material culture, is inherently dualistic. Craft skills and tacit knowledge that are required in successful conservation practice (see, for example, Muñoz Viñas 2022) allow the discipline to synthesize

Figure 6. Ethical considerations and craft skills evident in the use of tar to repair a crack in the scalp of a carved head. Image: Museum of Archaeology, University of Stavanger.

the tangible and the intangible simultaneously. Thus, traditions of practice contribute to processual authenticity in conservation, wherein tangible and intangible heritages are inextricably intertwined when tacit knowledge, traditional methods, materials and skills are successfully employed in modern conservation (Hassard 2008).

Stavanger cathedral's conservation history is also being examined through the lens of the biographical approach (Ebert 2019; Gosden and Marshall 1999; Kopytoff 1986), allowing comprehensive description of the cathedral's trajectory throughout history. The phases of conservation can be mapped, and their implications described in the light of contemporary approaches to repair and maintenance. In this manner, the biographical framework allows lines of comparison to be drawn between choices (material, practical, and theoretical) made by craftspeople in the past with present choices. By comparing medieval approaches to modern conservation, one can draw parallels between craft perspectives of artisans involved in cathedral construction and those charged with contemporary maintenance. When combined with comprehensive material characterization of historic tar samples, this allows mapping and explanation of the material choices made by medieval craftspeople, thus demonstrating their continued relevance for modern stone conservation. By developing a new adhesive formula based on rediscovered medieval knowledge, the project demonstrates the continued relevance of medieval craft skills in the present and future.

Sustainable adhesive technology

By focusing on traditional methods for conservation, the project outputs will contribute to the UN sustainable development goal (SDG) 11, sustainable cities and communities, target 11.4 of strengthening efforts to protect and safeguard the world's cultural and natural heritage. Medieval stone churches are more at risk with climate change, as wetter weather is linked to increased risk of damage (Hauglid et al. 2022). Now more than ever, it is therefore crucial to investigate adhesives which have withstood centuries, and to incorporate these into modern conservation practice. This novel discovery allows the reintroduction of lost medieval knowledge in the form of an 'extinct' traditional adhesive to the toolkit of the modern stone conservator, whose options are currently limited to materials not in keeping with principles of technological and processual authenticity.

The project aims to have a green impact on conservation practice by reducing dependence on synthetically-manufactured adhesives such as epoxy resins, instead exploring traditional natural renewable materials successfully employed in historic times. Once a modern tar adhesive mixture has been produced, lifecycle assessments can be run to compare the environmental sustainability of these in comparison with synthetic resins. Given that pine tar is traditionally obtained from old pine stumps, it is of course clear that the cutting down of old pine trees is not desirable in the context of finite natural resources. Nevertheless, there may be potential for using stumps from sustainably managed forestry or waste from timber industries in future tar production. This contributes to UN SDG 12, sustainable consumption and production patterns. By undertaking research that is related to sustainable development and our society's green transition, the project aims to contribute to minimizing the field's environmental impact and making modern conservation practice more sustainable by reducing reliance on synthetic adhesives.

Conclusion

The discovery of hundreds of medieval tar-based repairs on Stavanger cathedral, together with archival evidence pointing to the use of tarry adhesives during the Middle Ages, prompted the development of a research project on the topic of wood tars for adhesion and repair of stone. The *Sticking Stones* project investigates the historic use of tar adhesives in architectural stone repair, with the aim of developing a conservation adhesive based on wood tar. The

goal is to uncover the lost medieval tradition of tar repairs and use this new-gained knowledge of traditional materials and techniques in contributing to alternative adhesive use in modern stone conservation. In this manner, lost craft knowledge will be rediscovered and re-engineered for future traditions of practice, making conservation more sustainable by potentially reducing reliance on synthetic adhesives.

Historic methods and materials have significant potential in contributing to a more sustainable conservation practice, and it is hoped that this project will act as an impetus for similar approaches to materials and method development in conservation, using the past for inspiration. In developing alternative solutions for conservation, historic materials, methods, and techniques may offer more sustainable approaches than those currently in use.

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