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OVERVIEW OF WOOD–CONCRETE COMPOSITE SYSTEMS FOR STRUCTURAL APPLICATIONS

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This review outlines wood concrete composite systems for structural applications in buildings and bridges. The discussion classifies systems by timber product, including logs, sawn lumber, glued laminated timber, laminated veneer lumber, and cross laminated timber, and explains how a concrete layer coupled by shear connectors assigns compression to concrete and tension to timber to raise stiffness, span capacity, and floor or deck performance. The review compares common connection strategies and summarizes the design checks that govern practice, with serviceability and long-term deformation controlling building floors and fatigue, moisture, and waterproofing details controlling bridge decks. Evidence from recent studies shows that composite efficiency depends on connection stiffness and ductility, that vibration and acoustic targets in buildings can be met with measured connection properties and calibrated models, and that durability of the interface is the decisive factor in bridges. The paper highlights needs for verified long term models that couple slip, creep, shrinkage, and moisture, for connectors with stable performance in aggressive environments, and for clearer guidance for modern panel products. With careful selection of materials, connection detailing, and protective measures, wood concrete composites can meet structural, serviceability, and durability targets across a range of spans and exposure conditions.

Keywords: *wood concrete composite, glued laminated timber, laminated veneer lumber, cross laminated timber, connectors, serviceability, bridges.*

ДЕРЕВОБЕТОННЫЕ КОМПОЗИТНЫЕ КОНСТРУКЦИИ ЗДАНИЙ И МОСТОВ: ОБЗОР СОВРЕМЕННОГО СОСТОЯНИЯ

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В данном обзоре рассматриваются деревобетонные композитные системы, применяемые в несущих конструкциях зданий и мостов. В работе представлена классификация систем по типу используемых лесоматериалов, включая бревна, пиломатериалы, клееное дерево (glulam), брус из клееного шпона (LVL) и перекрестно-клееную древесину (CLT). Разъясняется принцип совместной работы, при котором бетонный слой, объединенный с древесиной при помощи связей сдвига, воспринимает сжатие, а древесина – растяжение, что позволяет повысить жесткость, увеличить пролеты и улучшить эксплуатационные характеристики перекрытий или мостового полотна.

В обзоре проводится сравнение распространенных способов соединения и обобщаются расчетные проверки, определяющие инженерную практику: при проектировании перекрытий зданий определяющими являются эксплуатационная пригодность и длительные деформации, в то время как для мостовых конструкций ключевыми факторами выступают усталостная прочность, влажностный режим и гидроизоляция. Данные последних иссле-

дований показывают, что эффективность композита напрямую зависит от жесткости и пластичности соединений; установлено, что нормативные показатели по вибрации и акустике в зданиях могут быть достигнуты при использовании измеренных характеристик соединений и откалиброванных моделей, а решающим фактором долговечности мостов является состояние контактного интерфейса.

В статье подчеркивается необходимость разработки верифицированных моделей длительной работы конструкций, учитывающих податливость соединений, ползучесть, усадку и влажность, а также потребность в соединительных элементах со стабильными характеристиками в агрессивных средах и в более четких рекомендациях по проектированию современных панельных изделий. При правильном подборе материалов, конструировании узлов соединения и принятии защитных мер деревобетонные композиты способны обеспечить требуемые показатели прочности, эксплуатационной пригодности и долговечности в широком диапазоне пролетов и условий эксплуатации.

Ключевые слова: *деревобетонные композиты, клееная древесина, шпоновый брус (LVL), перекрестно-клееная древесина (CLT), соединительные элементы, эксплуатационная пригодность, мосты.*

Introduction

Wood concrete composite systems pair a timber element with a concrete layer through shear connectors so that concrete primarily resists compression and timber resists tension, enabling higher bending stiffness and load capacity than non-composite layers while improving the vibration and acoustic behavior of floors and the durability of bridge decks [1]. In buildings, designers often mobilize a concrete topping that is already needed for leveling, services, fire, and acoustics to achieve longer spans with controlled deflection and comfortable floor response. In bridge decks, the concrete layer distributes wheel loads and shields the timber from wear and weather, while cyclic loading, connector fatigue, and moisture management become decisive checks for service life and maintenance planning [2]. Across both contexts, simplified mechanical models can guide preliminary design, but long-term behavior is governed by the combined effects of connector slip, concrete creep and shrinkage, and timber moisture variation, which motivates refined numerical analysis when plate action or time dependent effects are critical [3]. Connection technology remains central to composite efficiency and constructability, with current research focusing on notched interfaces, inclined screws, and glued in rods as well as their performance in demanding environments such as fire, where detailing and robustness strongly influence reliability [4].

Experiment section

1. Sawn lumber with concrete

Sawn lumber and concrete connected through screws or notches are widely adopted in building floors because the concrete topping that is needed for leveling and acoustics can be mobilized structurally to raise stiffness and control vibration while keeping construction practical at medium spans [5]. Recent system level studies show that the composite response is governed by connector slip and serviceability checks, and that calibrated vibration models can reliably predict footfall performance when the connection stiffness and damping are measured on representative push out tests [6].

2. Glulam with concrete

Glulam combined with a reinforced concrete slab provides a robust option for longer spans and bridge like actions because the timber carries tension efficiently while the slab adds compression capacity and a durable surface [7]. Experimental and analytical work on beams with ductile connectors shows consistent gains in bending resistance and deformation capacity when connector detailing ensures slip control and post yielding ductility under repeated loading [8].

3. Laminated veneer lumber with concrete

Laminated veneer lumber offers high and uniform in plane stiffness that benefits one way and two-way plate action when composited with concrete, and full-scale tests confirm that plate behavior can be exploited when support conditions and connector layouts are tuned for two-way load paths [9]. Lightweight beech LVL slabs with efficient steel tube or similar connectors demonstrate that weight reduction and span increase can be achieved together if shear transfer and orthotropy are explicitly treated in design models [10].

4. Cross laminated timber with concrete

Cross laminated timber and concrete composites deliver marked increases in floor stiffness and improved acoustic and fire performance compared with bare CLT, provided that rolling shear in cross layers and connector slip are accounted for in serviceability verification [11]. New experimental programs on CLT concrete floors address concentrated loading and vibration response in office scale spans and indicate that design targets can be met with reasonable connection densities and well characterized damping [12].

Table 1. – Overview of wood–concrete composite systems by timber product and application context

Application	Logs	Sawn lumber	Glulam	LVL	CLT
Buildings	Rare in buildings; reuse; irregular geometry	Joist and topping; mid spans; vibration control	Longer spans; serviceability governs	One way or two-way plates; uniform stiffness	Multi fold stiffness; acoustics and fire
Bridges	Short span decks; moisture detailing	Decks with screws or notches; durability focus	Bridge decks; fatigue and waterproofing	Lightweight decks; model orthotropy	Emerging use; rolling shear and damping

5. Design and verification framework

In practice, design of wood–concrete composite floors and bridge decks is governed by serviceability, durability of the interface, and construction-driven constraints. A pragmatic workflow begins with connection characterization, slip modulus, ductility, and fatigue resistance from push-out or component tests, followed by selection of an analysis level commensurate with the project aims. For preliminary sizing of one-way members, simplified composite beam formulations with partial interaction are adequate to establish section proportions and connector densities. When plate action, long-term effects, or concentrated loads are decisive, refined numerical models that include connector nonlinearity and orthotropy become necessary to capture stiffness sharing and stress redistribution [3; 6].

For building floors, the controlling checks typically include short- and long-term deflection under quasi-permanent actions, vibration response (modal frequencies and peak accelerations under walking), and acoustic/fire performance when the topping is part of the building physics strategy. Calibrated vibration models using measured connection stiffness and damping have shown reliable prediction of footfall performance, enabling rational connector layouts without excessive densities [6; 11; 12]. Long-term verification should explicitly combine timber moisture variation with concrete creep and shrinkage; otherwise, effective stiffness can be overestimated and crack risk in the topping or differential camber at interfaces may be underestimated [3].

For bridge decks, fatigue in connectors and waterproofing details generally controls service life. The concrete layer distributes wheel loads and shields timber from wear and weather, but cyclic loading demands ductile connection behavior with post-yield slip capacity and stable stiffness under repeated actions. Detailing should ensure robust load paths around joints, drainage paths that prevent ponding, and surfaces compatible with membrane or sprayed waterproofing systems. Field experience and tests indicate that interface durability, not ultimate strength in a single event—is often the limiting factor, so verification should emphasize connector fatigue demand (capacity), moisture management, and maintainability of the surfacing system [2; 8].

Connection mechanics ties these checks together. Higher slip modulus raises composite efficiency and floor stiffness but can elevate fatigue demand; conversely, ductile connectors distribute effects of differential movements (creep, shrinkage, moisture) at the expense of slightly lower initial stiffness. The design target is therefore a balanced specification: enough stiffness to meet deflection and vibration limits in buildings, with sufficient ductility and protected details to sustain cyclic demands and environmental exposure in bridges. When project constraints or exposure are severe, mock-ups or on-site dynamic measurements can close model gaps before committing to full-scale layouts [3; 6; 8; 12].

Conclusion

Wood concrete composite systems provide a practical route to raise stiffness, span, and floor or deck performance by assigning compression to concrete and tension to timber while maintaining construction efficiency. Across the five timber product families considered, the choice of connector and the treatment of long-term effects are decisive for reliability. In buildings, serviceability governs and designers can mobilize an existing topping to deliver controlled deflection, acceptable vibration response, and improved acoustic and fire performance with moderate connector densities. In bridges, cyclic loading, moisture exposure, and detailing for waterproofing and fatigue shape the design and maintenance plan, and the durability of the interface is often the limiting factor. Sawn lumber systems remain a cost-effective option for medium spans, glulam systems extend spans and are suitable for bridge like actions, LVL systems support one way and two-way plate behavior with uniform stiffness, and CLT systems benefit from clear verification of rolling shear and connector slip. Future progress depends on validated models that couple slip, creep, shrinkage, and moisture, on connectors with higher ductility and stable properties in aggressive environments, and on consistent guidance for modern panel products. With careful selection of materials, connectors, and protective detailing, wood concrete composites can meet structural, serviceability, and durability targets in both buildings and bridges.

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