REFERENCE	STUDY PARAMETERS/CRITERIA	FOCUS	GAP	FINDINGS
Akanbi, L. A., Oyedele, L. O., Omoteso, K., Bilal, M., Akinade, O. O., Ajayi, A. O., Davila Delgado, J. M., & Owolabi, H. A. (2019). Disassembly and deconstruction analytics system (D-DAS) for construction in a circular economy. Journal of Cleaner Production, 223, 386-396. https://doi.org/10.1016/j.jclepro.2019.03.172	* P = Construction performance over time * RU = The reusable fraction of building materials * CR = The recyclable fraction * y = The performance fraction * t = Age of building in year D15 * NC = Total number of connections * ne = Total number of possible building elements * ndc = Number of removable connections * nFb = Number of prefabricated assemblies * vBf = Volume of materials without secondary finishes * vm = Total volume of building materials * vhtl = Volume of material without hazardous content	Design of a disassembly/deconstruction analysis system (D-DAS: disassembly and deconstruction analytics system) to take into account end-of-life performance analysis from the design and construction process. Intergrate to BIM Developed national functions: - Analyses the performance of the building over its lifetime - Analysis of the deconstruction of elements - Design advice for deconstruction Applied to BIM (BIM plug-in or BIM visioner)	Quantifies the amount of materials that can be reused, not their potential for de-mixing.	This technique allows designers to try multiple combinations. Provides encrypted data. The plug-in offers alternatives to optimize the end-of-life of the building. Quantifies disassembly via DAS (Akinade et al. 2015)
Akinade, O. O., Oyedele, L. O., Bilal, M., Ajayi, S. O., Owolabi, H. A., Alaka, H. A., & Bello, S. A. (2015). Waste minimisation through deconstruction: A BIM based Deconstructability Assessment Score (BIM-DAS). Resources, Conservation and Recycling, 105, 167-176. https://doi.org/10.1016/j.resconrec.2015.10.018	* DAS = Deconstructibility Assessment Score * M = Material set, i.e. M = {M 1, M2, ..., Mn} * C = Set of components, i.e. C = {C 1, C2, ..., Cn} * E = Connector set, i.e, E = {E 1, E2, ..., En} * DMD = Design Model for Deconstructability * r1 = True if sample is reusable * r2 = True if sample is recyclable * P = True if sample is prefabricated * c = Connection type; c = {cf, cb, cn, cd} * cf = Fixed connection * cb = Bolted connection * cn = Nailed connection * cd = Connection with pins * n = Total number of samples * t = Sample material type; t = {steel, concrete, wood, etc.} * tn = Material type-number ratio for subsystem * x = True if sample is toxic * s = True if the material has secondary finishes * v = Sample volume in mm3 * q = Spatie position and orientation of the sample * p = Sample position in 3D space * r = Sample rotation in 3D space * Ew = Total waste at end of life * Bq = Total number of elements in the building * Tr = Total recoverable item in Bq * e = Residues * Ee = Energy lost at end of life * Ec = Total grey energy and energy required for the construction of the building	Creation of a mathematical model to evaluate the potential of a building by a score indicating the deconstructibility: Building information Modelling based Deconstructability Assessment Score (BIM-DAS) in the design phase. 3 objectives: -Identify critical design principles that ensure deconstructibility of the building. -Develop an objective system, i.e BIM-DAS to note the degree of deconstructibility of buildings -To test the performance and usability of BIM-DAS	Same weight for deconstruction and recovery score. Other criteria could be considered: material handling, ...	Calculation method developed: - Variables: materials, components, connection, number, position, orientation, toxicity, etc. - Output: Loss, lost energy, recoverable items, ... -> Weighted sum of Deconstruction Score & Recovery Score = DAS Score Subsystem organization: layers. Design of independent subsystems DfD Design Principles: - use of bolt rather than glue - Sustainable materials; - materials without secondary finishes - Non-toxic materials; - prefabricated assemblies + minimizes the number of type and number of components and connections Economically, (CostDfD) < (Value of Materials Recyclable) – (CostElimination)
CEN-TC 350-SC 1_N139_Gap consultation draft report	No study parameters since no method implementation to assess the disassembly potential	Reviews all the shortcomings of articles, standards, documents on the circularity of buildings.	Apart from a section on the potential for disassembly with DfD and Design for reuse, this document does not provide information on caulking methods for de-patching. It is only a review of the shortcomings of norms and studies about the circularity of buildings. Even if the subject of disassembly is addressed since it is part of the circularity of a building.	Standards about the reuse potential of a building should not only be on the structure but also on the whole building. Design/conception should be added with an indefinite life expectancy. In ISO 20887 it should add rules by categories (steel, concrete, wood, etc.) Studies should consider safety during demolition and deconstruction. Need a guide/standards and to reuse the building elements, to remove the "fear of reusing structural parts" The ease and ability to deconstruct and reuse is influenced by: - The type of connection - The weight of the materials - If the building is built on silla or with prefabricated elements H19
Cottafava, D., & Ritzen, M. (2021). Circularity indicator for residential buildings : Addressing the gap between embodied impacts and design aspects. Resources, Conservation and Recycling, 164, 105120. https://doi.org/10.1016/j.resconrec.2020.105120	** BCIplein = Building circularity indicator (full version) * BCIsimplified = Building circularity indicator (simplified version) * ICE = Element Circularity Index * Fd = Sum of all maximum weights * Fje = Nominal weight * fj = Weight factor of product j in PBCI formulation * Fri = Fraction of recycled material for product j * Fru =Fraction of material reused for product j * I = Design Criteria Index * IR = Intrinsic recyclability * J = Number of components for the whole building * j = Product Index * Js = Total number of components for layer s * Lavj = Average life of a similar product on the market compared to product j * Lj = Product life j * LFI = Linear Flow Index * LK = Level of Importance * LKs = Importance level for diapers * MCIp = Material circularity indicator for product p * Mj = Total mass of product	This essentially focuses on the development of a calculation method to quantify the circularity of a building. It therefore takes not only disassembly into account, but also reuse.	Does not present a method of calculation to evaluate the potential of disassembly but only a method to calculate a circuit index of buildings.	In this study, it is said that nowadays (in 2021) there is no globally recognized standard for design for disassembly because there are so many methods. Akinade et al. (2017) identified 15 factors grouped into 3 groups for DfD: - Material factors; - Design factors; - Factors related to site workers; They also identified 38 critical factors grouped into 5 categories: - Strong laws and policies - Deconstruction design processes and skills - Design for material reuse; - Design for material reuse; - Design for building flexibility Moffatt and Russell (2001) introduced some principles of DfAD: 1) durability, 2) versatility, 3) access to services, 4) redundancy, 5) simplicity, 6) scalability, 7) independence and 8) building information.
Dams, B., Maskell, D., Shea, A., Allen, S., Driesser, M., Kretschmann, T., Walker, P., & Emmitt, S. (2021). A circular construction evaluation framework to promote designing for disassembly and adaptability. Journal of Cleaner Production, 316, 128122. https://doi.org/10.1016/j.jclepro.2021.128122	Criterion: accessibility of components, disassembly safety, independence, standardization, reversibility and processing and finishing	Creation of the CCEF (Circular Construction Evaluation Framework) tool to quantify the level of circularity of a project. Application on 4 different type study cases (conventional materials, prefabrication with conventional materials, prefabrication with bio-sourced materials, modular construction). Implementation of international guidelines, including ISO 20887:2020. Concrete, steel, wood.	Unclear rating: how to know exactly in which percentage range the project is? No weighting of criteria.	The CCEF takes into account the criteria: Design (disassembly, adaptability, simplicity), safety, durability, materials, processing, connections. Each criterion is rated from 0 (not circular) to 5 (circular). If the criterion is rated yes or no, yes=5 and no=0. If the criterion is evaluated in %, the percentage is translated into a score of 0 to 5. Score of 0 to 5: - 0: <10% - 1: 10-29% - 2: 30-49% - 3: 50-69% - 4: 70-89% - 5: > 90% Result in table form, a section for the whole building and a section for the components/components. The maximum score that can be obtained is 70, which can be converted into a percentage to give an overall score to the building.
Denis, F., Vandervieren, C., & Temmerman, N. D. (2018). Using network analysis and BIM to quantify the impact of Design for Disassembly. Buildings, 8(8). Scopus. https://doi.org/10.3390/buildings8080113	Accessibility of the connection, * Transportability (related to the weight and volume of the material), * Resistance (breaking point for two elements linked by an irreversible connection), * Mass, * Reversibility of the connection, * Disassembly time, * Sequential dependency.	Development of a method: DNA (Disassembly Network Analysis) to quantify the impact of disassembly on buildings. Study the interdependence of the elements. Application of the method to 2 examples: a linear assembly and a complex assembly.	Calculation method that focuses more on technical results: estimated disassembly time, transportability of extracted components, ... rather than on a quantification of the disassembly potential. Could allow to have a score for the disassembly potential by subtracting the number of items recovered and the number of items lost?	Method divided into 4 steps: - quick check (determines if the item can be disconnected) - definition of potential paths (list of ways to access to break the connection) - quantification of parameters (disassembly time, number of items lost, ...) - Results
Durmisevic, E. (2006). Design for disassembly as a way to introduce sustainable engineering to building design & construction.	assembly sequence, accessibility of components, geometry of product edge, independence, standardization, processing and finitionconnection and element type, relational model type	Studies design for transformable buildings. Introduces all the main principles for disassembly. Also introduces the criteria scoring method.	Does not take environmental aspects into account	2 key criteria: independence (functional: design) and exchangeability (technical: hieratic order and physical: connections) Result: radial diagram. KPI for transformation: - functional decomposition - systematization and grouping - hierarchical relations between elements -specification of the basic component - assembly sequence - Interface geometry; - type of connection - Coordination of the assembly/disassembly life cycle+G36 Technical breakdown - relational pattern - Specification of the basic component Physical decomposition - edge geometry - assembly sequence - connection - Coordination of the assembly/disassembly life cycle; Functional decomposition - Functional independence - systematization
Grütter, C. et al. (not published) Design for and from Disassembly with Timber Elements: Strategies based on two Case Studies from Switzerland	accessibility of components, degree of freedom, disassembly damage, ease of assembly and disassembly, complexity of components, end-of-life waste, independence, manufacturing method, reusability, processing and finishing, structural strength			
ISSO 110250 Circulariteit in referentiedetails. (s. d.). ISSO. Consulté 7 juillet 2023, à l'adresse https://open.isso.nl/publicaties/isso-rapport-110250-circulariteit-in-referentiedetails/2021	accessibility of components, geometry of product edge, independence, type of connections.	The ISSO (2020) Reference Details report provides examples of assemblies of construction products and components that can be dismantled using detailed cutting plans	Written in Dutch, discusses the potential for disassembly of existing construction details, but not how these details can be improved with respect to disassembly	The construction details are based on the EU CPR definition for CE marked products. The report shows different types of connections and compositions for construction products and assesses the ease of disassembly to reuse dismantled components or construction products.
Rothner, C., Cencic, O., Honic, M., & Rechberger, H. (2022). Recyclability assessment at the building design stage based on statistical entropy : A case study on timber and concrete building. Resources, Conservation and Recycling, 184. Scopus. https://doi.org/10.1016/j.resconrec.2022.106407	* the number of materials (Nm), * the number of elements (Ne), * the mass of each material (Mi), * the total mass of the product (Mp), * mass shares of components (mi; mj = Mj / Mp) What will allow to calulse: * the concentration of each material (ci) * the static entropy (Hi) of each part, * total static entropy (Hp) Using the maximum hypothetical static entropy (Hmax), the "recyclability inherent in the relative product" RPR is calculated.	Reviews the technique of Honic et al. (2019). The document is based on a single building, which was designed to be subsequently disassembled. Calculation technique called RPR ("recyclability inherent in the relative product") which consists in calculating the recyclability rate of a building according to its composition and structure. It takes into account its components, sub-component and SSC. Applying this method, the dinal result is a percentage of recyclability. Demonstration of the method on a building designed and model thanks to a BIM software in wood or concrete. Use of a passport for different components.	Only take into account wooden and concrete structures. (see if there are others even if little used) Study carried out only on a building designed to disassemble. No verification on other buildings, already built.	The concrete building is more recyclable if no precise deconstruction is carried out (= gross demolition), but as the wooden building uses a higher number of materials, at the level of SC and even SSC, this allows a higher recyclability rate. The RPR decreases as a building's materials are mixed.
Sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements and guidance ISO 20887:2020. Consulté le 7 juillet 2023.	component accessibility, disassembly security, independence, connection type, standardization, simplicity supporting buiness model, processing and finishing.	Aims to provide a framework for DfD/A principles and key points that need to be questioned by construction stakeholders, thus allowing these principles to be integrated into the project. Applicable to any type of building and civil engineering work and any type of project (new construction, renovation, etc.) The principles described in the document must be applied to the main components, (neglecting items that might be obsolete ex: vetilation system). Deals with environmental, social, economic, technical and functional aspects	The document is not intended to establish a method for calculating the disassembly potential. He draws up a successful guide with simple ratings (yes/no or 0 to 5). He has no hierarchy of the citéres or overall rating.	The principles to be considered vary according to the study scenario. For example, one principle will be preferred over another depending on the service life of the study building. 3 design principles for adaptability: - versatility (accommodate diverse functions with little change) - convertibility (anticipating the possibility of changing users' needs) - extensibility (allows the addition of new spaces, capacity, ...) 7 design principles for disassembly: - Easy access to components; - independence - Avoid unnecessary treatment and finishing - Support for economic models of reuse; - simplicity - standardization - Disassembly safety 5 levels of study: system, components and assembly, sub-component, materials. " Appendix C: Above guide to measuring DfD without hieratic criteria. Criteria that can be grouped as a checklist in a matrix. - Easy access to components (0 to 5); - independence (0 to 5) - avoid unnecessary treatments and finishes (yes/no) - Support for economic models of reuse (% or yes/no); - simplicity - standardization (% by category dimension, component, connection, modularity, interoperability) - disassembly safety (0 to 5)
van der Zwaag, M. (2022). Data-Driven Decision-Making for Circular Building Design : Development of an automated decision-support framework for an improved circular design workflow. https://repository.tudelft.nl/islandora/object/uuid%3Ad4752ebd-7d70-4136-b0d7-685fc070ac56	accessibility of components, geometry of product edge, independence, type of connections.			
Van Vliet, M., Van Grinsven, J., Teunizen, J. (2021). Circular Buildings Meetmethodiek Losmaakbaarheid version 2.0. Alba Concepts.	* Type of connections, * accessibility of the connection, * independence, * geometry,	Method for calculating the disassembly potential under construction Scope: - to develop easily disassembled connections Improved version compared to 2019 thanks to feedback and recommendations	Calculation method that seems to be the most accurate.	The potential for detachability is not an indication of circularity alone. The method must therefore be applied in relation to other principles of circularity. Assign a score between 0 and 1 for each parameter based on the reference table provided. Implementation of an equation containing all the parameters (weighted) to calculate the disassembly potential of each plus set of the building as a whole.
van Vliet. (2018). *Disassembling the steps towards Building Circularity*.	* Accessibility to connection * Type of relational pattern * Assembly sequence * Method of fabrication * Independency * Assembly shape *Type of connection * Deconstruction safety * Disassembly instructions * Disassembler expertise * Number of operations * Disassembly costs	a revision of the calculation method of the circularity indicator BCI (Building Circularity Indicator) (Verberner, 2016). The study focuses on the indicator «disassembly possibility of a building» which alone represents 50% on BCI result. It tends to validate the assumptions made during the development of the BCI and to refine the method for calculating the disassembly potential.		
Xiao, J., Zeng, L., Ding, T., Xu, H., & Tang, H. (2023). Deconstruction evaluation method of building structures based on digital technology. Journal of Building Engineering, 66, 105901. https://doi.org/10.1016/j.jobe.2023.105901	* Development * Ed = total energy released during deconstruction processes * Eq = energy required for deconstruction * Er = energy resource of deconstructed objects * ε = energy released for other reasons (losses) * Dr = extent to which the building structure element can be deconstructed * Rr = N that can be recycled * Gold = environment or location of the building * Si = ratio of different structural forms * di = component connection mode ratio * n = ratio between prefabricated elements or directly decomposable units *pi = ratio of components or units to the position in the building structure to be deconstructed * R1 .. Rn = resource form of each structural element after deconstruction * tm and sm = external conditions (toxic or sufficient) * hm = human factors * pm = technical process * mm = construction methods * i = type of relevant influencing factors * n = total number of structural parts * CCI = cost of deconstruction * RPR = cost of materials directly recyclable and deconstructed * CDL = cost saved by waste disposal * ACCI = the cost of modifying the secondary use of components after deconstruction of the structure, * CTI = transport cost due to resource use * CDI = deconstruction cost * CRI = cost of resource use	Development of a method to evaluate the deconstruction of building structures using a laser scanning technique. This non-contact scanning technique would assess deconstruction, improve safety and facilitate the transformation of destructive demolition into optimal demolition		New method of scanning buildings.