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## Osnovno

- Zadržavanje toplote
  - Geometrija zgrade
  - Toplinska izolacija
  - Toplinska masa
  - Zrakonepropusnost
- Kontroliranje transporta vlage
  - Difuzija vodene pare
  - Transport likvidne vlage
  - Kiša nošena vjetrom



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## Primjer loše prakse



**"Visionary" £7m eco-school to be demolished because of leaky roof**

The school was meant to be one of the first zero carbon primary schools to be built in the country.

Izvor:  
<https://www.telegraph.co.uk/news/2016/08/03/visionary-7m-eco-school-to-be-demolished-because-of-leaky-roof/>

By: Telegraph Reporters  
8 AUGUST 2016 - 3:00PM

- Izgrađena 2010.
- Napuštena 2014.
- Srušena 2016.
- Sagrađena nova 2018. za 6 m£

One of Britain's first eco-schools which cost £7 million when it was built just six years ago is to be demolished because of a leaky roof.

Plans have been unveiled to scrap the abandoned eco-school at Dartington, Devon and replace it with a new £6 million facility.

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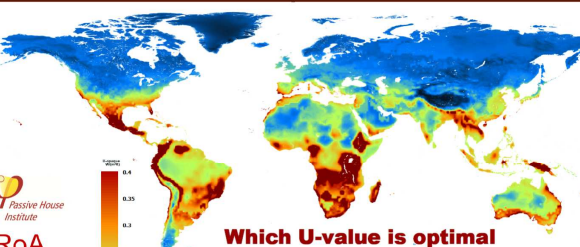
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## Climate – Climatic Conditions



**RoA**

**Which U-value is optimal for which Climate?**

**Schnieders / Feist / Rongen**

**Which window-type?**

**Which ventilation mode?**

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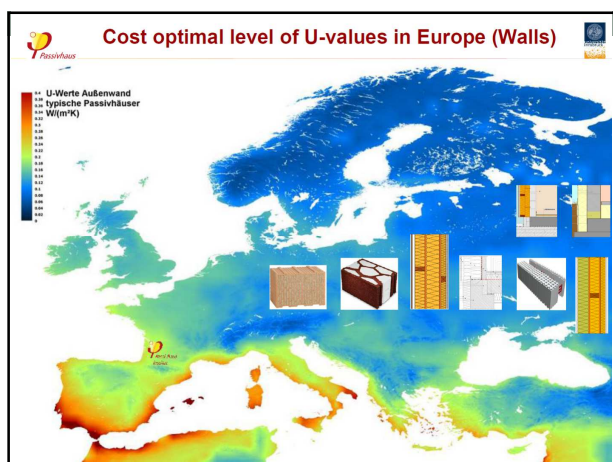
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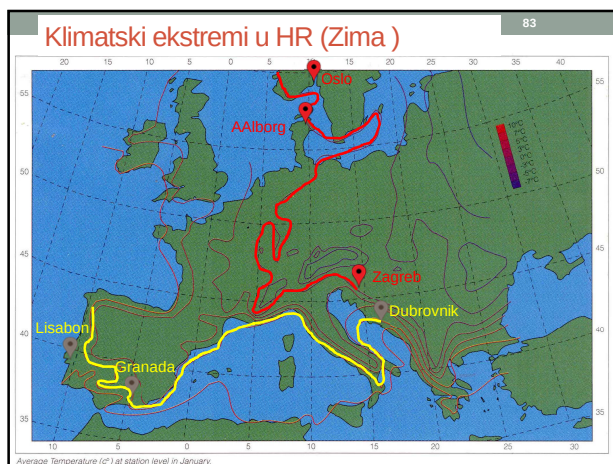
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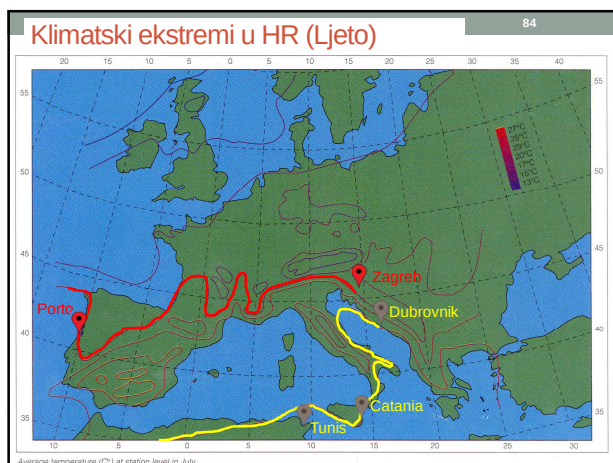
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when buildings **DO** reflect the local climate

DESERT CLIMATE   TEMPERATE CLIMATE   TROPICAL CLIMATE

when buildings **DON'T** reflect the local climate

DESERT CLIMATE   TEMPERATE CLIMATE   TROPICAL CLIMATE

Izvor: Doris Oesterreicher  
The role of smart buildings for energy efficiency

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## Dinamičke toplinske karakteristike

- Plošna masa fasadnog sustava osigurava vrlo dobre dinamičke toplinske karakteristike sustava.
- Za istu U-vrijednost, a različiti toplinski kapacitet sustava...

| Thermal Mass (kg/m²)          | Dynamic Thermal Characteristic (D) |
|-------------------------------|------------------------------------|
| Very lightweight (w < 100)    | 1.33                               |
| Lightweight (100 ≤ w < 250)   | 1.15, 1.08, 1.21                   |
| Medium-weight (250 ≤ w < 400) | 1.12, 1.08, 1.06, 1.04             |
| Heavyweight (400 ≤ w < 550)   | 1.03, 1.02, 1.00                   |
| Very heavyweight (w ≥ 550)    | 0.99, 0.98, 0.99                   |

• Doprinos HDD = 3466.0  
• Karlovač HDD = 2036.5  
• Šibenik HDD = 1661.0  
• Zagreb HDD = 1173.4

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## Pasivne strategije

### Pasivne strategije grijanja

- Izravno sunčevo zračenje
- Trombe zid
- Zimski vrt
- Korištenje topline zemlje

**Osnovni princip:**

- Prikupi – akumuliraj – distribuiraj

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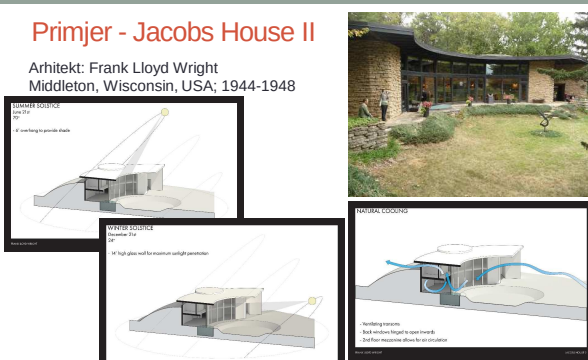
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### Primjer - Jacobs House II

Arhitekt: Frank Lloyd Wright  
Middleton, Wisconsin, USA; 1944-1948



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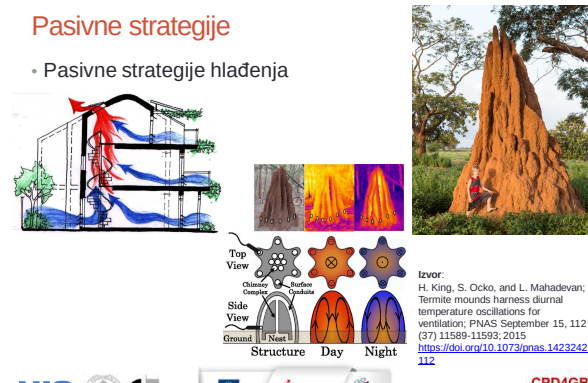
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### Pasivne strategije

- Pasivne strategije hlađenja



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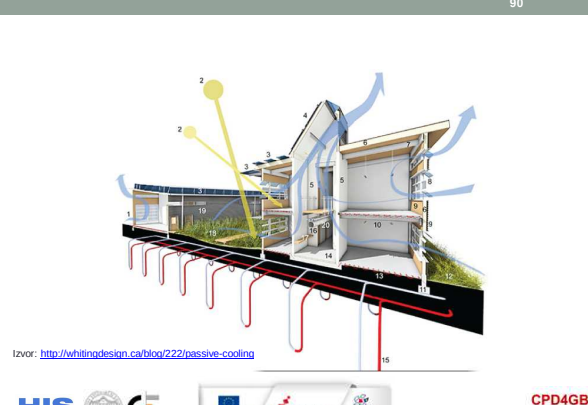
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## Manitoba Hydro Place

- The design uses the building's **concrete thermal mass** to mitigate extreme temperature swings and integrate radiant heating and cooling systems, with a **solar chimney to provide 100% fresh air by moving exhaust air** to the bottom of the chimney to combine with the atria's preconditioned air and preheat incoming cold air to within room temperature



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## PROJEKTNII ZADATAK

Variraj parametre...  
Pronađi optimum!



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## KOJE MATERIJALE KORISTITI?



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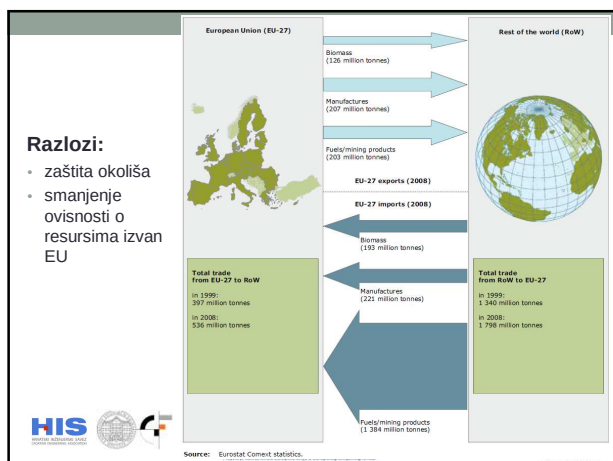
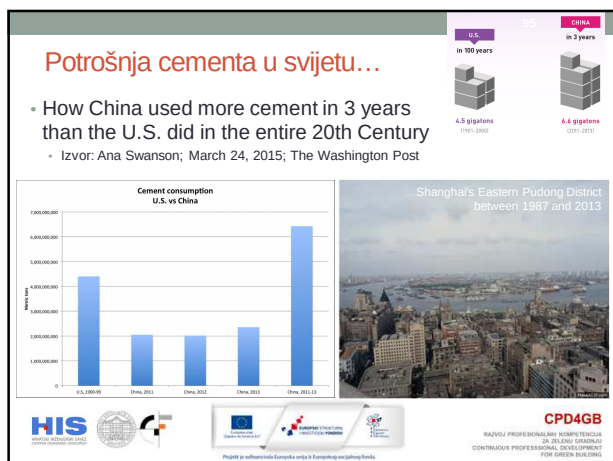
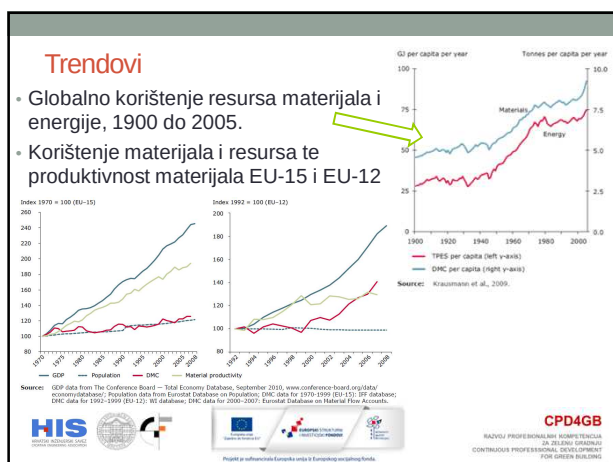
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## IZBOR GRAĐEVNOG MATERIJALA

• Kriteriji za ekološku prihvatljivost materijala

- imati najmanji mogući utjecaj na okoliš
- trošiti malo energije
- biti moguće reciklirati
- biti proizveden u blizini
- biti energetski učinkovit
- biti dugotrajan
- proizvoditi minimalne količine otpada
- imati dobar društveni utjecaj
- biti jeftin



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## Materijali Prirodni vs Sintetički

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Primjer

**ECOSE<sup>®</sup> TECHNOLOGY**

- Ecose<sup>®</sup> mineralna vuna proizvodi se
  - korištenjem **recikliranih staklenih boca, otpadnog stakla, otpada nastalog u samoj proizvodnji mineralne vune**, (85 % sirovina koje se koriste) te silicijskog pijeska.
- BRE Green Guide (BREEAM sustav)
  - materijal **ne sadrži štetne tvari poput formaldehida, fenola, pentana, butana i akrila**
  - za proizvodnju potrebno **do 70 % manje energije** nego u slučaju **tradicionalne mineralne vune**

**breeam**

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## Ocjena Ecosse® mineralne vune

breeam

| Utjecaj na okoliš                        | Izolacijski materijal od staklene vune – gustoća 32 kg/m³ | Ovčja vuna gustoće 25 kg/m³ | Slama kao TI |
|------------------------------------------|-----------------------------------------------------------|-----------------------------|--------------|
|                                          | Ocjena                                                    | Ocjena                      | Ocjena       |
| Emisija CO <sub>2eq</sub>                | B                                                         | B                           | A+           |
| Korištenje vode                          | A+                                                        | A+                          | A+           |
| Korištenje prirodnih resursa             | A+                                                        | A+                          | A+           |
| Degradacija ozonskog sloja               | A+                                                        | A+                          | A            |
| Toksičnost za čovjeka                    | A+                                                        | A+                          | C            |
| Toksičnost za pitku vodu                 | A+                                                        | B                           | E            |
| Nuklearni otpad                          | A+                                                        | A+                          | A+           |
| Toksičnost za tlo                        | E                                                         | E                           | A            |
| Odlaganje otpada                         | A+                                                        | A+                          | C            |
| Korištenje fosilnih goriva               | A+                                                        | A+                          | A+           |
| Eutrofikacija                            | A+                                                        | B                           | C            |
| Potencijal fotokemijskog stvaranja ozona | A+                                                        | A+                          | B            |
| Potencijal stvaranja kiselih kiša        | A+                                                        | A+                          | B            |
| Ukupna ocjena                            | A+                                                        | A+                          | A            |

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- Prirodni
  - minimalno prerađeni u industriji (drvo, slama, kamen, ...)
- Sintetički
  - Industrijski proizvedeni, prošli kroz značajne obrade i manipulaciju (polimeri, ...)

**Obje vrste imaju prednosti i nedostatke**

- dokazano da se često prirodni materijali ne mogu nositi sa sintetičkim
- **Potrebno vrednovanje ovisno o postavljenim kriterijima**

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## Koliko je materijal zelen?

- Protupitanje...
  - Koji je kriterij?
- Je li kriterij...
  - Trajnost materijala
  - Obnovljivost materijala
  - Mala utrošena energija...
    - u proizvodnji
    - kod prijevoza i ugradnje
    - tijekom korištenja
    - tijekom razgradnje
  - Bez štetnih sastojaka i emisija za korisnike, radnike i okoliš
  - Cijena
  - ...



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## Transport materijala

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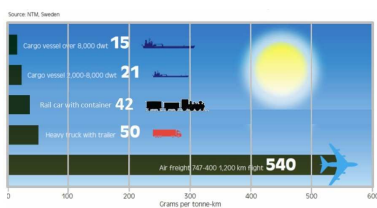
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## Utjecaj transporta na okoliš?

- Usporedba emisije CO<sub>2</sub> različitih načina transporta



Izvor: 2013 VA Governor's Transportation Conference Ed McCarthy, SVP & COO  
<https://slideplayer.com/slide/3224537/>

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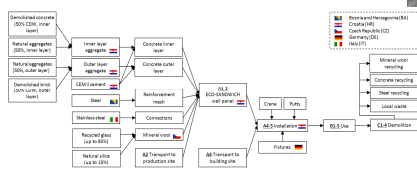
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## Primjer – ovčja vuna

- U Hrvatskoj se striženjem dobiva cca 1200 t/god
- Ne skuplja se i ne obrađuje u značajnim količinama
- Na tržištu ovčja vuna iz drugih zemalja EU i BiH
- **Utjecaj transporta** na ekološki otisak proizvoda?
- Nije odgovarajuća za sve primjene!



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### Higrotermalna svojstva materijala

- Difuzija vodene pare
- Apsorpcija i desorpcija vlage - Reguliranje RH prostora

ili

Primjer glinene žbuke

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### Sigurnost

Požar – Grenfell Tower London  
Izvor: [www.BBC.com](http://www.BBC.com)

Požar – studentski dom Cvjetno naselje, Zagreb  
Izvor: [www.Srednja.hr](http://www.Srednja.hr)

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## PROJEKTNI ZADATAK

Variraj materijale...  
Pronađi optimum!



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## OTPAD... ILI RESURS?



There will be  
no difference  
between waste  
and energy.



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## Očuvanje prirode ili iskorištavanje resursa?



Rezervat biosfere pod zaštitom UNESCO-a



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## OTPAD: Problem ili Novi Resurs?

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## Dansko iskustvo

- Danska je 2004. g reciklirala **94% CDW-a!!!**

| Year | Recycling (%) | Incineration (%) | Landfill (%) |
|------|---------------|------------------|--------------|
| 1984 | 15            | 85               | 0            |
| 1994 | 54            | 44               | 2            |
| 2004 | 94            | 4                | 2            |

Source: Ekonet (2006a), Country fact sheet Denmark

The waste hierarchy, as defined by the Waste Framework Directive (2008/98/EC)

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## Temeljni zahtjevi za građevinu

- 7. Održiva upotreba prirodnih izvora
  - Građevina mora biti projektirana, izgrađena i srušena tako da je upotreba prirodnih izvora održiva i da je posebno zajamčena:
    - ponovna upotreba ili recikliranje građevine, njezinih materijala i dijelova nakon rušenja
    - trajnost građevine
    - upotreba sirovina i sekundarnih materijala u građevini u skladu s okolišem
- Uredba 305/2011 Europskog parlamenta i Vijeća od 09.03.2011. koja propisuje usklađene uvjete trgovanja građevnim proizvodima i ukida
- Zakon o gradnji - u izradi

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### Primjer - Waldspirale

- Stambeni kompleks u Darmstadtu izgrađen tijekom 1990-tih
  - Arhitekt: Friedensreich Hundertwasser
- Izgrađena korištenjem 12.000 m<sup>3</sup> recikliranog betona
  - Smanjenje korištenja prirodnih resursa – pijeska i šljunka
  - Smanjenje količine otpada nastalog rušenjem.

Izvor: Wikipedia.org

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### Slama... Otpad ili resurs?

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## Gradnja slamom

- gradnja slamom je izuzetno jeftina (15× u odnosu na opeku ili beton)
- trend u svijetu-VB-nekoliko tisuća objekata godišnje



**HIS**  
Hrvatski Inženjerski  
Sustavi



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## Primjeri...



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Sustavi



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## Dekonstrukcija postojećih zgrada i gradnja nove

kuća ČV1 - Kupinečki Kraljevec, 2008

Arhitekt: Ljubomir Miščević

- Otpadna opeka – obloga ovojnice prizemlja
- Dekonstrukcija stogodišnjeg štaglja – obloga ovojnice 1. kata



**HIS**  
Hrvatski Inženjerski  
Sustavi



Projekt je sufinanciran Europskim fondom za regionalni razvoj i Fondom za regionalni razvoj.

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## Dekonstrukcija postojeće zgrade i gradnja nove

- Osnovna škola Brezovica pri Ljubljani
- Arhitekt: Slavko Gabrovšek





- rušenje stare zgrade
- razdvajanje građevinskih materijala
  - pažljivo uklanjanje,
  - razdvajanje
  - zaštita
  - priprema za ponovnu ugradnju



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## Dekonstrukcija postojeće zgrade i gradnja nove

Izvor: Slavko Gabrovšek, arhitekt

- Opeka
- Krovne ploče
- Fasadne ploče
- Keramičke pločice







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## PREDGOTOVLJENA GRADNJA?



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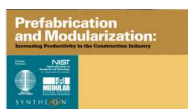
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## Održivost predgotovljene gradnje?

### • McGraw-Hill Construction

- ...This reemergence of prefab and modular **as a "new" trend is tied to the rise of BIM and green building, critical new trends** identified by McGraw-Hill Construction and other industry leaders....



McGraw Hill Construction provides essential data, news, insights, and intelligence to better inform construction professionals' decisions and strengthen their market position.



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## PREDNOSTI PREDGOTOVLJENE GRADNJE

### • Ključne prednosti:

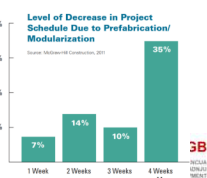
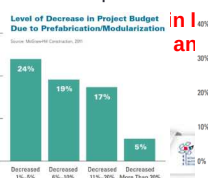
- **Brzina gradnje (do 70% brža gradnja),**
- **Ekonomičnost i**
- **Kvaliteta gradnje**

Izvor: OXFORD BROOKES UNIVERSITY

- This approach can offer **faster, cleaner and safer working conditions on site** and so be of benefit to clients, contractors and others involved in the process.

### • Consequently

Izvor: McGraw-Hill Construction  
The data are based on a survey of 809 contractors, architects and engineers.



## PREDNOSTI PREDGOTOVLJENE GRADNJE

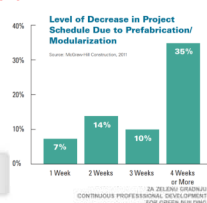
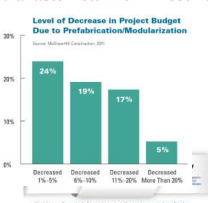
### • Ključne prednosti:

- **Brzina gradnje (do 70% brža gradnja),**
- **Ekonomičnost i**
- **Kvaliteta gradnje**

Izvor: OXFORD BROOKES UNIVERSITY

- This approach can offer **faster, cleaner and safer working conditions on site** and so be of benefit to clients, contractors and others involved in the process.
- Consequently, there are **savings in land, labour, rents, overheads and financing costs, and a faster return on investment.**

Izvor: McGraw-Hill Construction  
The data are based on a survey of 809 contractors, architects and engineers.



## Održivost predgotovljenih sustava

- Report - **Journal of Industrial Ecology** (Quale et al 2012)
- **prefabricated construction has fewer impacts, on average, than on site construction for all environmental impact categories studied.**
  - ...**noise and traffic congestion are also greatly reduced** as a result of decreased on-site construction, along with decreased pollutants...
  - ...the issue of **recycling and waste is potentially more manageable** in modular building...
    - the assembly line techniques associated with off-site factory construction allow predictability and consistency among parts;
    - this **significantly reduces building waste** of modular constructed projects.
  - ...the modularity increases **the ease associated with the disassembling of parts required in order to recycle building materials after the building is no longer used.**



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## OUT OF THE BOX THINKING



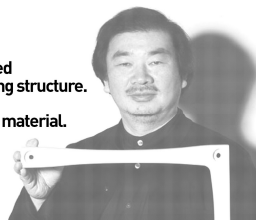
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I believe that the material doesn't need  
to be strong to be used to build a strong structure.  
The strength of the structure  
has nothing to do with strength of the material.

Shigeru Ban



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### Primjer promišljanja - Shigeru Ban




Nosači od papira

Izvor: <https://www.designboom.com/architecture/shigeru-ban-onagawa-temporary-container-housing-community-center/>

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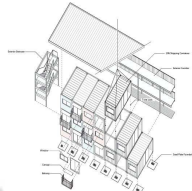
### Primjer promišljanja - Shigeru Ban

- used **steel shipping containers** to construct what was planned to be temporary accommodations for **displaced persons after an earthquake in 2011**.
- The scarcity of flat land led to the development of a 3-storey structural framework to allow stacking the 6m units in checkerboard fashion.
- Its amenity and excellent seismic performance allowed the building to be used as a permanent solution

Izvor: <https://www.designboom.com/architecture/shigeru-ban-onagawa-temporary-container-housing-community-center/>



Temporary housing , Onagawa, Japan



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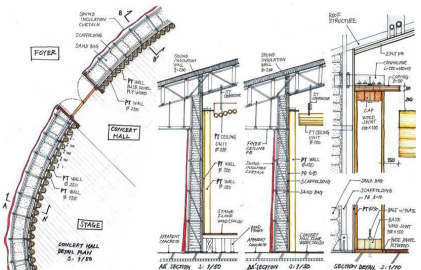
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### Primjer promišljanja - Shigeru Ban

- Paper Concert Hall - L'Aquila / Italy / 2010




Izvor: <https://www.designboom.com/architecture/shigeru-ban-paper-concert-hall-in-laquila/>

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### Primjer promišljanja - Shigeru Ban

- **Temporary substitute** for the Conservatorio Alfredo Casella that was destroyed in the 2009 earthquake.
- The temporary hall built of a number of different materials including **cardboard can be taken apart and re-used** at another location after reconstruction of the permanent hall.
- Students from three different countries helped with the construction.

HIS



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### SIMPLICITY OF THE SOLUTION, BORN OUT OF NEED

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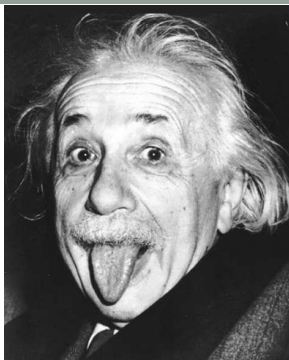


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"Make everything  
as simple as possible, but  
not simpler."

HIS



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# ANKETA

Green building survey...











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Projekat je sufinansiran iz opštinskog budžeta i Evropske unije kroz partnerstvo razvijanja kvaliteta.

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## Zelena gradnja?

Da / Ne?

### Ugrađena energija (Embodied energy) - info

Izvor: [https://en.wikipedia.org/wiki/Embodied\\_energy](https://en.wikipedia.org/wiki/Embodied_energy)

| Materijal | M3/kg | Materijal      | M3/kg | Materijal            | M3/kg | Materijal      | M3/kg |
|-----------|-------|----------------|-------|----------------------|-------|----------------|-------|
| Čelik     | 20,1  | Armirani beton | 1,9   | Drvo sušeno na zraku | 0,5   | Glineni crijep | 6,5   |
| Aluminij  | 155   | Opeka          | 2,5   | Cementni mort (1-3)  | 1,33  | Bale slame     | 0,91  |

## SOCIJALNI ASPEKTI?

Izvor:

[https://www.moma.org/interactives/exhibitions/2010/smallscalebigchange/projects/primary\\_school.html](https://www.moma.org/interactives/exhibitions/2010/smallscalebigchange/projects/primary_school.html)

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Hrvatski Inženjerski  
Savez

**CRS**  
Croatian  
Research  
Service

Projekt je sufinanciran zajedničkim ulozima iz Europskog i državnog budžeta.

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FOR CHOSEN CAREER

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# GRADILIŠTE

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### Primjer – Terminal Franjo Tuđman - Bouygues

ENVIRONMENTAL PROTECTION

GREEN STAR

Quality, Safety & Environmental

HIS

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### Primjer – Terminal Franjo Tuđman - Bouygues

Insect hotel

water is

Save water, save life

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## PRIMJER LCA

PRIMJER LCA

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## Rezultati LCA analize



U životnom ciklusu od 50 godina

- Smanjenje korištenja energije za 46%
- Smanjenje emisije CO<sub>2eq</sub> plinova za 39%

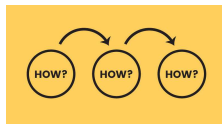
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## Projektni zadatak...

- Kvalitetna analiza i traženje optimuma u pogledu
  - Potrošnje energije s variranjem svih parametara u arhitektonsko-građevinskom, strojarskom i elektrotehničkom smislu
  - Odabir materijala i proizvoda s minimalnim utjecajem na okoliš
- Traženje globalnog optimuma...
  - ogroman broj kombinacija i mogućnosti!
- Je li put korištenje BIM-a!



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## ECOLOGICAL

Zapamtite!!!

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# BE SMART

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- **Specific:** State exactly what you want to accomplish (Who, What, Where, Why)
- **Measurable:** How will you demonstrate and evaluate the extent to which the goal has been met?
- **Achievable:** stretch and challenging goals within ability to achieve outcome. What is the action-oriented verb?
- **Relevant:** How does the goal tie into your key responsibilities? How is it aligned to objectives?
- **Time-bound:** Set 1 or more target dates, the "by when" to guide your goal to successful and timely completion (include deadlines, dates and frequency)



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# HVALA!

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[bmilovanovic@grad.hr](mailto:bmilovanovic@grad.hr)



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