High Quality Cold Recycling

The new way of road renewal

Egli-Total-Recycler

Virtually **no need** to take away of material
Virtually **no need** to dispose of material (e.g. tar)
Virtually **no need** for new materials (only binders)
Virtually **no need** for on-site deliveries (only binders)
Virtually **no need** for major energy input
Virtually **no air pollution**
Virtually **no water pollution**
Virtually **no risk to health**
Virtually **no loss of quality** (in accordance with standards)

The **quick and economical** solution

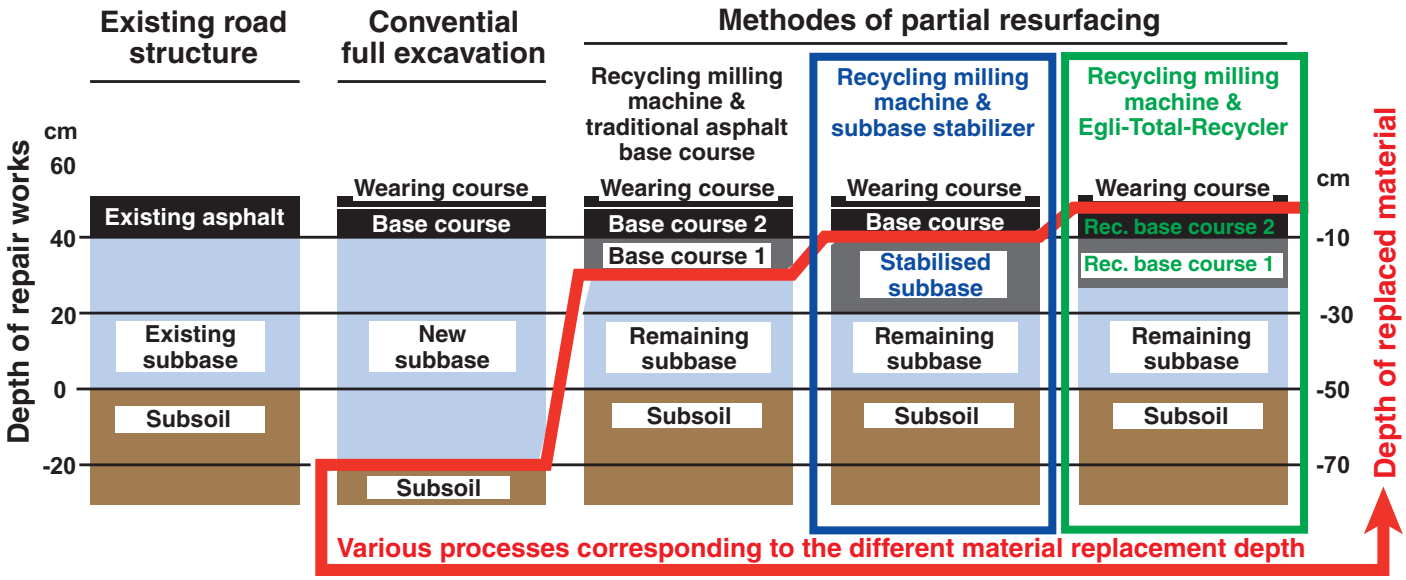
egli-kaltverfahren.de

Egli Kaltverfahren GmbH
Eggisried 37, D-87724 Ottobeuren

Tel. +49 (0) 8332 1404, Fax +49 (0) 8332 1493
e-mail info@egli-kaltverfahren.de, Internet www.egli-kaltverfahren.de

Application of cold recycling

Cold recycling can be applied wherever a road already exists. A simple fact, but it means that large quantities of existing old road material are not replaced but reused. This process is carried out on-site. In principle, this is an alternative to traditional full-scale construction, or rather an alternative to the well known 'partial road surface renewal'. In the case of 'partial road surface renewal' only as much of the road surface is dug out as absolutely necessary. Only the upper layers are renewed, using the material that is available on-site as far as possible. **'Partial road surface renewal' saves materials, transportation, time and money.** By employing subbase stabilizers and cold recycling machinery there is **no process energy** consumption either.



What is cold recycling?

With cold recycling the asphalt gets removed (including that containing tar) plus cement stabilizers or old gravel layers. These materials then go through the following processes:

1. Old material is **milled out** in layers and **segregated by type.** In preference a cold milling machine is used.
2. Old material is **crushed** to a standardized gradation (e.g. 0–32, 0–45, poss. 0–63 mm standard)
3. It is then **screened** in order to particularly guarantee that all the material lies inside the grading curve.
4. According to required specification, **1 to 4 bonding agents** are added.
5. Reclaimed material and bonding agents are then **thoroughly mixed.**
6. The new mixture is then **laid** and **compacted.**

Varying qualities are obtained depending on the method, ranging from simple stabilizing of the ground up to standardized high-quality recycling using mobile machinery.

Why cold recycling?

In Europe, in contrast to the USA, cold recycling of roads is relatively new. The **ever increasing quantities of old materials generated,** such as removed asphalt, old stabilizers and gravel subbases, cold recycling is achieving greater importance.

The increasing flood of restrictive **laws in respect of the reuse** of removed asphalt, in particular with regard to the use of heat to recycle asphalt containing tar, cold recycling is now favoured to a much greater extent for these materials.

A further point in favour of this method is that cold recycling represents a very **economical form of reutilization** of reclaimed materials. The various methods of recycling have in the meantime delivered the required proof of good quality and the total recycling machine (Egli-Total-Recycler)

will produce a quality product in **accordance with the norm.**

Finally, cold recycling is the most resource efficient form of reutilization of old materials. This minimizes or completely eliminates the requirement for transport and new materials.

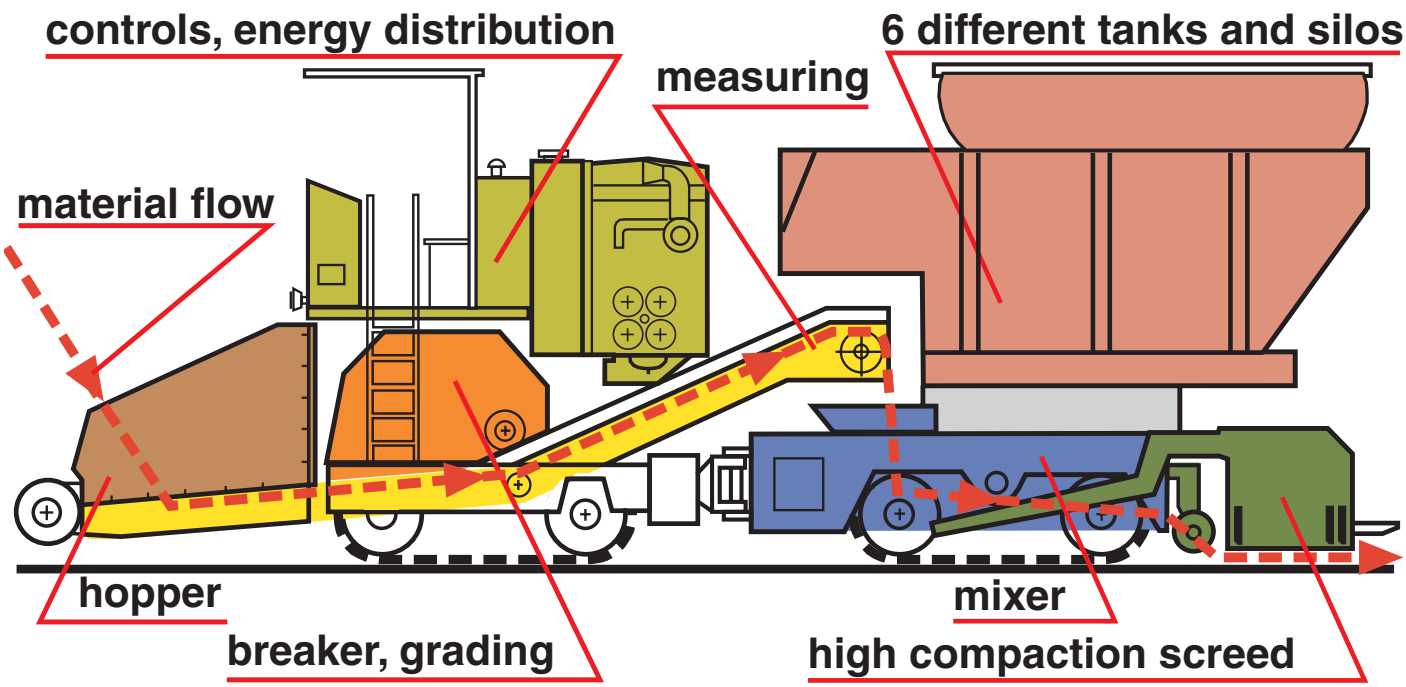
These factors, together with the energy savings when compared to those associated with the production of new material insures this method's **outstanding environmental credentials.**

Cold recycling by means of the Egli-Total-Recycler (mobile high-quality cold recycling)

The Egli-Total-Recycler accepts all kinds of basic materials, such as various grades of gravel, recycled material, tarry asphalt etc., having a maximum granular size of 200 mm. These are crushed down to a size of less than 50 mm, graded and mixed cold with up to 4 types of binding agents, simultaneously or in sequence and laid to the precise height by means of an extendable high compaction screed.

The Egli-Total-Recycler is a globally unique machine. In contrast to a subbase stabilizer it provides a **defined crushing** and **screening** of the old material, so that this keeps to the **well-known standardized grading curves** of 0–32 mm or 0–45 mm, according to the type of work. The uniform mineral is now **measured** under **defined conditions** in kg/min. The value is entered into the onboard computer as a reference for the binding agents. Binding agents like cement, bitumen emulsion and water (and possibly some additives) are metered in with the same **high degree of accuracy** as in a stationary plant and thoroughly mixed using the **integrated mixer.** After the mixer the bituminous material is laid to the precise height by means of an **extendable high compaction screed.**

After some deployment in Switzerland, the Egli-Total-Recycler has carved out its own market, and is widely accepted in Germany: In the first few years it was mainly used as a high-quality disposal method for tarry scrap asphalt and recently as a high-quality but inexpensive method for the reuse of normal reclaimed asphalt or gravel sub bases.



Road renewal process by means of the Egli-Total-Recycler

1. Surface removed with a heavy cutter: The machine cuts through the asphalt and roadbed to a depth of over 30 cm, leaving a perfectly leveled surface.

2. Intermediate storage: The spoil is taken to a nearby storage area. Any materials containing tar are covered over with sheeting.

3. Material for recycling: The asphalt comes out in slabs while the gravel is often very coarse-grained.

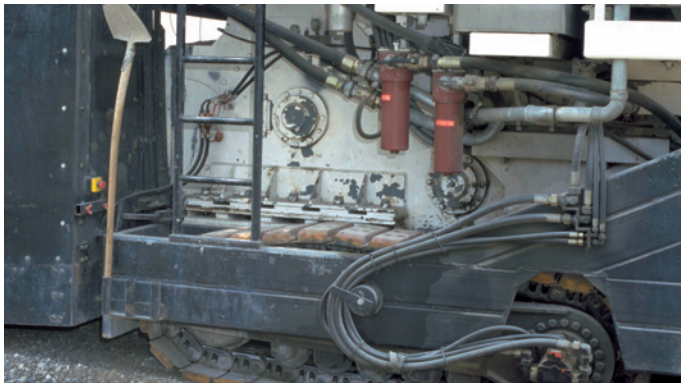
4. Strength test: If the remaining sub base is too weak in places, the material is replaced.

5. Transportation of the machine: The 60 tonne machine is transported to the site intact and can be unloaded and reloaded in a very short time. The operating weight is approx. 100 tonnes.

6. Loading of bonding agents: The bonding agents are loaded according to the suitability test. (e.g. bitumen emulsion, cement, water, additives).

7. Recycling and laying: All the processes described in this sequence take place inside the machine.

8. Take-up of materials: The salvaged material, generally very coarse or in slabs is tipped into the hopper.



9. Crushing and screening: As the reclaimed material is usually far too coarse-grained for immediate reuse, it is passed to an integral crusher and reduced to smaller than 50 mm then screened (reclaimed asphalt to 0–32 mm).

10. Precise measurement: Just before the broken and uniform aggregate enters the mixer, it is measured electronically by four sensors under precisely defined conditions.

11. Adding of bonding agents: The computer-controlled system takes up to 4 bonding agents from the 6 different tanks and silos and introduces them into the mixer.

12. Thorough mixing: The mineral is now thoroughly mixed with the bonding agents required by the suitability test inside the 2.5 m twin shaft paddle mixer.

13. High compaction laying: The machine has an electronically levelling high-compaction screed that can be extended to between from 2.5 to 6 m. This ensures precision laying even if the base is not even.

14. High-quality cold recycling: The machine breaks the materials down to less than 50 mm and measures the material under precise conditions. The computer-controlled system adds up to 4 additives and the materials are then intensively mixed. Finally, the resulting mixture is precisely laid under electronic control and highly compacted.

15. After laying: Not only does the completed sub-base and/or road surface maximize the efficient use of materials available on site, but it also complies with existing standards as if new materials had been supplied from a static plant.

16. Highest possible productivity: Milling out of the old road, direct loading onto lorries and transportation to the total recycling machine. Parallel charging of the total recycling machine with bonding agents during preparation and laying.

Binders

Stabilizing with cement (HGT=Hydraulisch gebundene Tragschicht=hydraulically bound bearing layer)

(Semi-) Static systems, subbase stabilizers and also cold recycling machines are all suitable for cement stabilizing, even when special cements are used. The subbase stabilizer is suitable for low-quality renewals (e.g. hydraulically bound subbase layer, HGF), for high-quality i.e. standardized subbase and bearing layers (e.g. HGT), only with the exception of static systems or the Egli-Total-Recycler.

Cement stabilizing delivers the well-known high strength but has the disadvantage that the asphalt layers above it tend to crack. Therefore, above every cement stabilizing layer a SAMI (Stress Absorbing Membrane Interlayer) needs normally to be inserted before laying hot asphalt, as this will absorb any stresses.

Stabilizing with bitumen emulsion

Stabilizing with bitumen emulsion is still little known, though it is defined in the norms of many states. This kind of stabilizing is likely to experience an upsurge as a result of cold recycling. Bitumen emulsions can only be used in static breaking and mixing systems or in the Egli-Total-Recycler, since the method requires a very exact metering of the binder. However, this can only be guaranteed where the reclaimed material for reuse has been crushed to a defined standard. In addition, the demands on the mixing of reclaimed material and bonding agents are considerably higher than with cement aggregate and require a precise metering of the bonding agents as well as a big mixer.

Materials stabilizing with bitumen emulsion do not quite reach the same level of strength as with cement, but on the other hand there is no danger of cracking and therefore no need for a SAMI either. Although the initial strength comes up to only about 80–90% of the final strength, this does not prevent, based on experience, the laying of further bearing and surface layers as early as the following day.

Stabilizing with cement and bitumen emulsion (complex recycling)

Stabilizing of reclaimed material with a combination of bitumen emulsion and cement (plus water and possibly an additive to control the breaking point) may become the way forward. Using this combination, known in Germany as complex recycling, the benefits of pure cement and bitumen emulsion stabilizing are almost achieved, but without incorporating their disadvantages.

In the case of complex recycling a distinction is drawn between stabilizing with a high degree of cement or of bitumen. For a twin-layer cold recycling installation, as an example, the lower layer has a high cement content (e.g. 4–5% cement and 1–2% bitumen emulsion) and the upper layer a high bitumen content (e.g. 3–4% bitumen emulsion and 1–2% cement). Above these the bituminous bearing or surface layers are placed, according to the weight of traffic anticipated. Using this procedure, the material stresses are dispersed without causing cracking, thanks to the increasing bitumen content from bottom to top and this makes a SAMI unnecessary. On the other hand, the strength is increased along with the increasing cement content from top to bottom.

Complex recycling does though have further benefits. The cement binds a part of the free water in the bitumen emulsion hydraulically, shorting the time to achieve the final strength. In addition the tar (poly aromatic hydrocarbons) in tarry reclaimed asphalt is bound in a better fashion by means of cold recycling, so as to protect it from being washed out into the environment.

Stabilizing with other binders

Reclaimed material can, at least theoretically, be stabilized with other binders. For reasons of quality, or rather price, only stabilizing with 'foaming bitumen' is likely to proliferate to an extent, based on the current state of road-building technology.

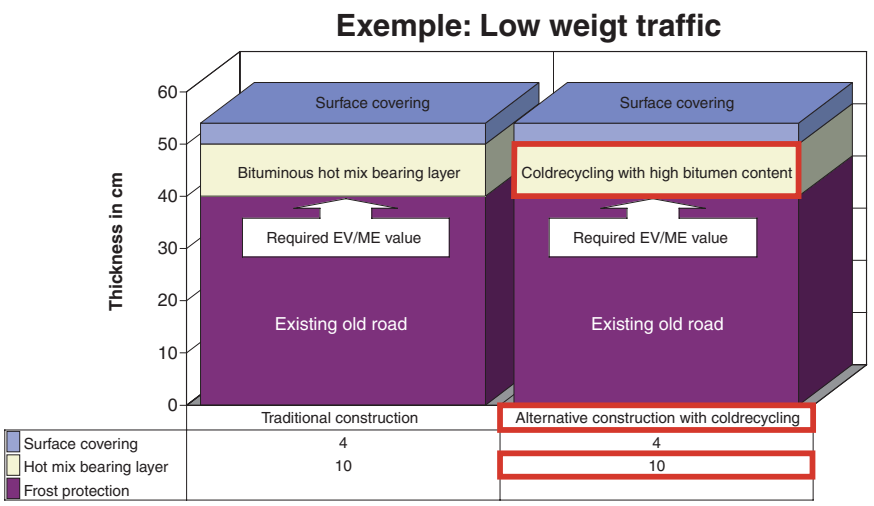
For this method, hot bitumen is mixed with a small amount of water before being sprayed into cold salvaged material and this causes the bitumen to foam. Thanks to the 10 to 20 times higher volume of the foam, the mineral can be coated in bitumen even when cold.

Within this paper, no further details of this kind of stabilizing will be given.

Comparisons between traditional and alternative works

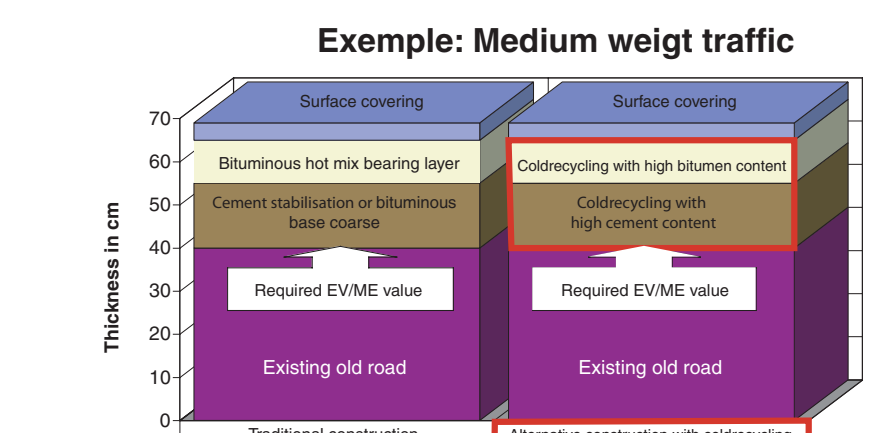
Road surfaces given below are simply dimensional examples from Swiss and German norms (VSS or RstO Standardisation) and are to serve as illustrations. Dimensions for frost protection and EV or ME values are to be established by engineers.

For roads with a **low weight of traffic** the bituminous hot mix bearing layer will be replaced by a cold mix bearing layer of reclaimed asphalt. Complex recycling with a high bitumen content will be employed, i.e. 3–4% bitumen emulsion and 1–2% cement will be added to the reclaimed asphalt, making full use of the cements strengthening effect. A final surfacing layer will be placed on top of it.



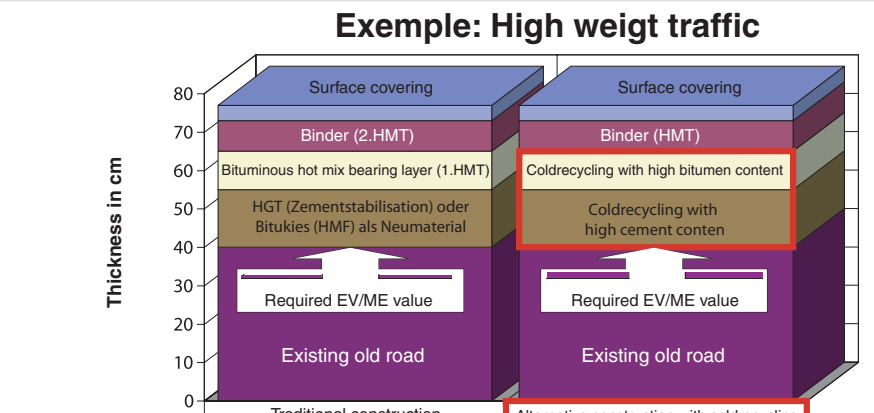
	Traditional construction	Alternative construction with coldrecycling
Surface covering	4	4
Hot mix bearing layer	10	10
Frost protection		

For roads with a **medium weight of traffic** the cement stabilisation or the bituminous base coarse is replaced by a coldrecycling with high cement content, made of a dug out gravel bed or of reclaimed asphalt. The bituminous hot mix bearing layer will be replaced by a complex recycling of milled out reclaimed asphalt, high in bitumen content. On top of this will be placed a surface covering. That way, highest possible strength will be achieved, thanks to the cement and highest possible elasticity, thanks to the bitumen.



	Traditional construction	Alternative construction with coldrecycling
Surface covering	4	4
Hot mix bearing layer	10	10
Foundation layer	15	15
Frost protection		

For roads with a **high weight of traffic** the same alternative construction will be carried out as for medium weight of traffic, though this will be overlaid with a binder or a bituminous hot mix bearing layer and a surface covering. Thanks to an increased cement content from top to bottom high stability will be achieved and thanks to an increased bitumen content from bottom to top high elasticity. Material stresses will thus be dispersed and there will be no need for a SAMI.



	Traditional construction	Alternative construction with coldrecycling
Surface covering	4	4
Binder (2.HMT)	8	8
Hot mix bearing layer (1.HMT)	10	10
Foundation layer	15	15
Frost protection		

Outstanding conservation of resources

Cold recycling of available reclaimed materials is probably the most environmentally friendly way of reutilization. Thanks to the employment of subbase stabilizer and above all of the Egli-Total-Recycler there is:

Virtually no need for taking away of material: Thanks to the direct reutilization of reclaimed materials there is no transportation requirement to a disposal site, but just for short trips within the construction site. This way no diesel is used up, there are no exhaust fumes and no noise pollution is caused.

No need to dispose of material: Reclaimed material that has not been carted away, likewise does not need to be disposed of. This is of special importance where the reclaimed asphalt contains tar, the disposal of which would be extremely expensive. Quite apart from that, the dumping of high-grade construction materials is quite senseless anyway.

Virtually no need for new materials: Apart from a small quantity (by weight) of binder, the reclaimed material is totally used. No new minerals need to be quarried and purchased. The countryside can be protected from this environmental damage.

Virtually no need for on-site deliveries: Minerals not being used have likewise no requirement for delivery.

Virtually no need for process energy: Hot aggregate consumes about 12 l of fuel oil per ton during production (for 10'000 tonnes that is 120'000 l, the annual consumption of 40 houses for heating and hot water and it exhausts about 315'000 kg of CO^2). Incidentally, the hot aggregate is only heated (process energy) so that it can cool down again after preparation and laying. Cold preparation does not use any process energy (only diesel energy for engines).

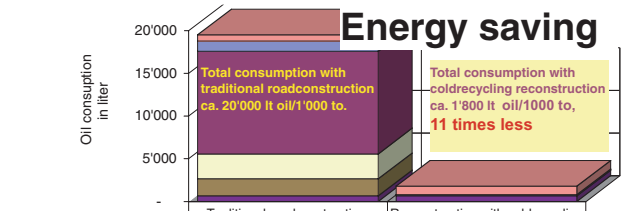
Virtually no air pollution: Where there is no need to heat up materials, similarly nothing is burnt. Where nothing is burnt there are no smells and neither CO_2 or other exhaust gases are given off. The 120'000 litres of fuel oil mentioned above are not needed and do not have to be extracted, refined or transported. Because unused fuel oil can not leak out anywhere, no beaches will be polluted either.

No water pollution: The integration of tarry reclaimed asphalt into the mix, by means of complex recycling, prevents the washing away of the subbase or bearing surface laid down. Water pollution is practically excluded (only when using a high quality cold recycling machine like the Egli-Total-Recycler).

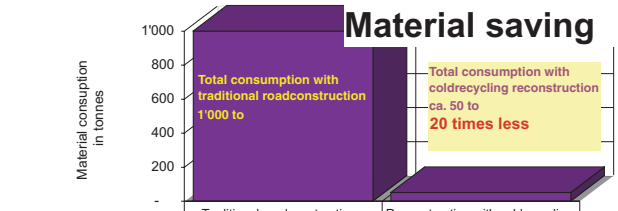
Virtually no risk to health: Cold recycling of reclaimed asphalt works without process energy. It emits no smoke and no vapours (VOC) and therefore no ozone at ground level. Due to the absence of motor transport, there is neither noise nor are there accidents on the roads. Cold recycling is not toxic and apart from engine emissions presents no risk to health, neither for the site staff nor nearby residents.

No loss of quality: Cold recycling by means of the Egli-Total-Recycler supplies standardized material of the same quality as if it had been crushed and sized by a modern static crushing and screening plant and then mixed by a static mixing plant (centralized mixing process). Resulting in a more environmentally friendly manner and with excellent conservation of resources.

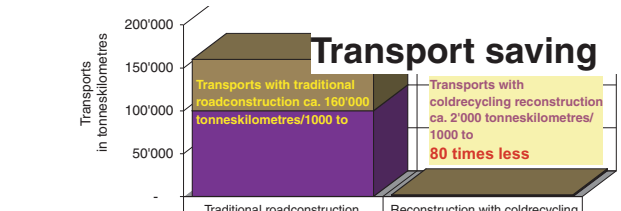
Environmental conclusions: The diagrams refer to the most important environmental parameters in road construction: Energy consumption, use of materials and transportation requirement. In this the following case is assumed: For the traditional construction method 1000 tonnes of tarry reclaimed asphalt is dug out, transported (50 km) and dumped (e.g. tar) and the same quantity of new hot asphalt prepared, transported (30 km) and laid. With cold recycling 1000 tonnes of tarry reclaimed asphalt are milled out, temporarily stored (500 m), cold prepared and relaid.



	Traditional roadconstruction	Reconstruction with coldrecycling
Asphalt laying and compaction	750	1'000
Transport to the site	1'200	60
Production of hot asphalt	12'000	0
Energy content of new mineral	2'900	0
Transport to the deposit site	2'000	60
Milling out of old asphalt	650	650



	Traditional roadconstruction	Reconstruction with coldrecycling
New material	1'000	50



	Traditional roadconstruction	Reconstruction with coldrecycling
Transport from the site	60'000	1'000
Transport to the deposit site	100'000	1'000

Road recycling thought out: In theory it is hardly possible to make road recycling even more **conserving of resources** and **economical,** at the same time as keeping to existing standards. The result is a complete closure of the product cycle and a multiple utilization of materials is ensured. That's it, road recycling thought out.

Internet: This illustrated documentation can be called up in four languages (German, French, Italian and English) at **www.coldrecycling.com**

Examples of mayor contracts

1995/96, A4, CH-Winterthur
30'000 tonnes to HGT
(Cement stabilizing from regional salvage materials)

1998, B2 motorway, D-Augsburg
10'000 tonnes, highest constr. quality
(Parallel loading, preparation and laying)

2004, B469, D-Obernburg
12'000 tonnes of tarry asphalt to HGT
(In the foreground: material storage, at the backround: preparation and laying)

2005, motorway B2, D-Augsburg
25'000 tonnes of tarry asphalt to HGT
(Material collected in a bigger area by highway authorities)

Examples of combined works

1997, By-pass, D-Wildsteig
3000 tonnes of tarry asphalt in a nature reserve
(Left: cut out road and material depot)

2000, Motorway BAB A7, D-Altenstadt
5000 tonnes milled asphalt to HGT
(Milling of asphalt, direct transport back, Preparation and relaying)

2001, bypass road, D-Konstanz
6000 tonnes of tarry asphalt to HGT
(In the backround: milling out of old asphalt, left: preparation and laying)

2003, road realignement, D-Heimendingen
3000 tonnes, 80% tarry material, 20% gravel to HGT
(Right: milling, left: preparation and laying)

Technical data of the Egli-Total-Recycler

Engine		
Manufacturer		Cummins
Type		QSX15-C530
Cooling		Water
Number of cylinders		6
Output	kW/hp	395/530/537
Engine speed	rpm	1800
Displacement	litres	15
Electrical system	V	24

Dimensions and weights		
Dead weight	metric tons	60
Operating weight	metric tons	100
Transport dimensions	LxWxH in m	11.8x3.1x3.6

Capacities		
Fuel, diesel	litres	900
Hydraulic fluid	litres	1000
Water/emulsion	litres	2x4500
Cement	kg	20’000

Production		
Crusher/screening system	mt/h	250
Twin-shaft compulsory-type mixer	mt/h	250
Mounting width	m	2.55–5.00
Straight crossfall	%	-2.5 to+5
High compaction		yes

Handling		
Operating speed	m/min	0-50
Travel speed	km/h	0–3.5
Climbing capacity during operation	%	20
Climbing capacity during travel	%	5
Ground clearance	mm	180
4 crawler units	L/W/H in m	2.5x0.5x0.8

Miscellaneous		
Electrical system	V	12
Electronics		PLC
Computer logging		Yes

Remarks:

Further examples of works with the total recycling machine

1996, mountain road at 1500 m above seal level, CH-Mels, 2000 t of bearing layer
(Dug out asphalt from nearby motorway)

1996, By-pass, D-Pöking
3000 t of ballast liquid (tar)
(Complex recycling bit. emuls. + cement)

1996, A6, D-Dachau,
6000 t of HGT from a flooded gravel pit
(Standardized hydr. bound bearing layer)

1997/98, Res. street, D-Augsburg
5000 t of tarry asphalt
(Laid with camber, height from kerb stones)

1997, A96 motorway, D-Munich
3000 t of tarry asphalt to HGT
(Cut out asphalt from regional salvage materials)

1997, through road, D-Hirten
3200 t of tarry asphalt to HGT
(Material stored for several months)

1998, Village through road, D-Ueberacker
2200 t of tarry asphalt
(High bitumen complex recycling)

1999, Local connecting road, D-Rossberg
6100 t of tarry asphalt to HGT
(Material broken to less than 50 mm)

1999, Trunk road, D-Jengen
2500 t tarry asphalt to bit. stabilizer
(Direct utilization by client)

1999, Residential street, D-Leitershofen
5900 t tarry asphalt to HGT
(Centre pivot steering, no laying problems)

1999, Trunk road, D-Hahnennest
3600 t tarry asphalt to HGT
(Compacted by rollers or slabs)

1999, Forest road, D-Legau
2400 t of tarry asphalt to HGT
(Temporary storage onsite)

1999, Trunk road, D-Altomünster
3600 t of tarry asphalt to bit. stabilizer
(>10'000 m² complex recycling)

2000, parking area, D-Günzburg
5000 m², contaminated material to HGT
(Left: preparation and laying, center: chip seal coating)

2001, Motorway, CH Zurich
8000 t, different waste materials to HGT
(Different Materials collected by high way authorities)

2001, new quarter, D-Bad Tölz
10'000 tonnes of tarry asphalt to HGT
(3 layers with different recipes, excl. final layer)

2004, residential street, D-Flächenrieden
4000 t of tarry asphalt to HGT
(No mayor problems in narrow situations)

2006, motorway B19, D-Waltenhofen
4000 t of tarry asphalt to HGT
(At the backround: milling of old asphalt, middle: preparation, laying, compaction)

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Egli Kaltverfahren GmbH
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Tel. +49 (0) 8332 1404, Fax +49 (0) 8332 1493
e-mail info@egli-kaltverfahren.de, Internet www.egli-kaltverfahren.de